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"CUNNINGHAM MEMOIRS."

No. IV.

DYNAMICS AND MODERN GEOMETRY:

A NEW CHAPTER
IN THE
THEORY OF SCREWS.

BY

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No. IV.

DYNAMICS AND MODERN GEOMETRY,

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conditions necessary to render the geometrical methods applicable. The only restrictions which we shall impose are thus stated:—

(1). The material system consists of a single rigid body.
(2). The body has two degrees of freedom.
(3). The investigation only applies while the body remains in or near to its original position.

It will be observed that the forces are generally unrestricted, though in some cases it will be found that they should belong to what is often known as a 'conservative' system. Nor is the nature of the constraints prescribed in any way, except that they shall so limit the body that any position it is capable of assuming can be specified by two co-ordinates. The third condition expresses the well-known limit to the operation of the Theory of Screws. The effect of this condition is to confine our inquiries to four departments, as follows:—1st. The kinematics of small movements; 2nd. The theory of equilibrium; 3rd. The theory of impulsive forces; 4th. The theory of small oscillations.

I refer to the *Theory of Screws*[1] for the demonstrations of the fundamental theorems that are required. I commence by reciting three laws which govern the displacements of a body which has two degrees of freedom.

(1). A body with two degrees of freedom can twist about all the screws of a singly infinite system.
(2). The axes of all these screws form the generators of a conoidal cubic surface, which is called the *cylindroid*, and of which the equation is

$$z(x^2 + y^2) - 2mxy = 0.$$

(3). Each screw has a specific pitch appropriate to its situation on the cylindroid.

§ 2. **Representation of the Cylindroid by a Circle.**—The essence of the present Memoir lies in the geometrical representation of a screw by a point. The series of screws which constitute the cylindroid correspond to, or are represented by, a series of points in a plane. By choosing a particular type of correspondence we can represent the screws of the cylindroid by the points of a circle. The problems in this Memoir are studied by the aid of the corresponding circle. We are conducted to this circle by two methods, one of which shows that the relation of the circle to the surface is not merely casual or artificial. This method will form the subject of a future communication, and for the present let it suffice to choose a very simple process for the discovery of the circle, though it must be admitted that the method now used will hardly suggest to the reader those developments of anharmonic and homographic theories which will be found later on in this Paper.

---

[1] *Theory of Screws*, by R. S. Ball. Dublin: Hodges & Figgis, 1876.

It is shown (*Theory of Screws*, p. 15) that the positions of the several screws on the cylindroid may be concisely defined by the intersections of the pairs of planes,

$$y = x \tan \theta,$$
$$z = m \sin 2\theta.$$

In these equations, θ varies in correspondence with the several screws, while m is a parameter expressing the *size* of the cylindroid. In fact, the whole surface, except parts of the nodal line, is contained between two parallel planes, of which the perpendicular interval is $2m$.

The pitch of the screw corresponding to θ is expressed by

$$p = p_0 + m \cos 2\theta,$$

where p_0 is a constant.

Eliminating θ between the equations for z and p, we obtain

$$(p - p_0)^2 + z^2 = m^2.$$

Let p and z be regarded as the current co-ordinates of a point. Then the locus of this point is the circle which forms the foundation of the present Memoir.

Any point on this circle being given, then its co-ordinates p and z are completely determined: m is, of course, the radius, and p_0 is the distance of the centre from a certain axis. Thus $\sin 2\theta$ and $\cos 2\theta$, and, consequently, $\tan \theta$, are known. We therefore see that the position of a screw and its pitch are completely determined when the corresponding point on the circle is known. To each point of the circle corresponds one screw on the cylindroid. To each screw on the cylindroid corresponds one point on the circle. This simple correspondence is the origin of the present theory.

§ 3. **The Axis of Pitch.**—Let T (fig. 1) be the origin. Then p_0 is the perpendicular distance ST of the centre S from the axis PT. The ordinate AP is the pitch of the screw, and the line PT may be called the *axis of pitch.* We have, accordingly, the following theorem:—

The pitch of any screw on the cylindroid is equal to the perpendicular let fall from the corresponding point on the axis of pitch.

A parallel AA' to the axis of pitch cuts the circle in two points, A and A', which have equal pitch. The diameter perpendicular to the pitch axis intersects the circle in the point U of maximum and V of minimum pitch. These points, of course, correspond to the two principal screws on the cylindroid. The two screws of zero pitch are defined by the two real or imaginary points in which the axis of pitch cuts the circle.

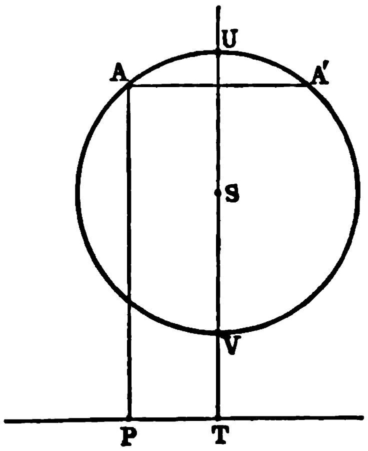

Fig. 1.

A fundamental law of the pitch distribution on the several screws of a system is simply illustrated by this geometrical representation. The law states that if all the pitches be augmented by a constant addition, the pitches so modified will still be a possible distribution (*Theory of Screws*, pp. 19, 85). So far as the cylindroid is concerned, such a change would only mean a transference of the axis of pitch to some other parallel position. The diameter $2m$ merely expresses the size of the cylindroid, and is, of course, independent of the constant part in the expression of the pitch.

§ 4. **The Distance between two Screws.**—We shall often find it convenient to refer to a screw as simply equivalent to its corresponding point on the circle. Thus, in fig. 2, the two points, A and B, may conveniently be called the screws A and B. The propriety of this language will be admitted when it is found that everything about a screw can be ascertained from the position of its corresponding point on the circle.

Let us, for instance, seek the shortest distance between the two screws A and B. Since all screws intersect the nodal axis of the cylindroid at right angles, the required shortest distance is simply the difference between the values of $m \sin 2\theta$ for the two screws: this is, of course, the difference of their abscissæ, *i. e.* the length PQ. Hence we have the following theorem:—

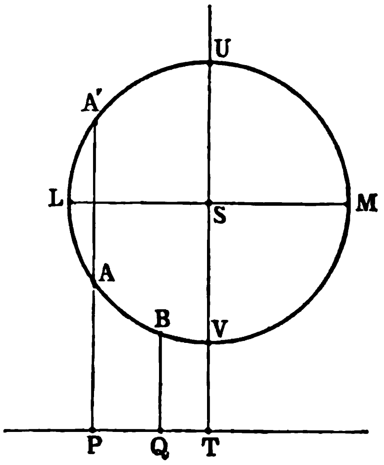

Fig. 2.

The shortest distance between two screws, A and B, is equal to the projection of the chord AB on the axis of pitch.

We thus see that every screw A on the cylindroid must be intersected by another screw A', and the chord AA' is, of course, perpendicular to the axis of pitch. A ray through S, parallel to the axis of pitch, will give two screws, L and M. These are the bounding screws of the cylindroid, and in each a pair of intersecting screws have become coincident. The two principal screws, U and V, lying on a diameter perpendicular to the axis of pitch, must also intersect.

If all the pitches be reduced by p_0, then the pitch axis passes through the centre of the circle, and the case assumes a simple type. The extremities of a chord perpendicular to the axis of pitch define screws of equal and opposite pitches, and every pair of such screws must intersect. The screws of zero pitch will then be the bounding screws, while the two principal screws will have pitches of $+m$ and $-m$, respectively.

§ 5. **The Angle between two Screws.**—This important function also admits of a simple representation by the corresponding circle. Let A, B, as before, denote the two screws; then, if θ and θ' be the angles corresponding to A and B (fig. 3),

$$AST = 2\theta; \quad BST = 2\theta',$$

whence $ASB = 2(\theta - \theta')$.

If H be any point on the circle, then

$$AHB = \theta - \theta',$$

whence we deduce the following theorem:—

The angle between two screws is equal to the angle subtended in the circle by their chord.

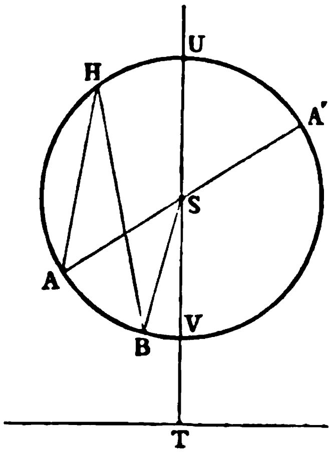

Fig. 3.

The extremities of a diameter denote a pair of screws at right angles: thus, A', in fig. 3, is the one screw on the cylindroid which is at right angles to A. The principal screws, U and V, are also seen to be at right angles.

The circular representation of the cylindroid is now complete. We see how the pitch of each screw is given, and how the perpendicular distance and the angle between every pair of screws can be concisely represented. We may therefore proceed to the dynamical theory, which gives to the cylindroid its interest, and we commence by proving a fundamental principle very analogous to an elementary theorem in Statics.

§ 6. **The Triangle of Twists.**—It is shown in the *Theory of Screws*, p. 17, that any three screws on the cylindroid possess the following property:—

If a body receive twists about these screws, so that the amplitude of each twist is proportional to the sine of the angle between the two non-corresponding screws, the body, after the last twist, will be restored to where it was before the first.

With the circular representation of the cylindroid we transform this theorem into the following:—

If any three screws, A, B, C (fig. 4), be taken on the circle, and if twists be applied to a body in succession, so that the amplitude of each twist is proportional to the opposite side of the triangle ABC, then the body will be restored by the last twist to the place it had before the first.

From the analogy of wrenches, and of twist velocities to twists, we are also able to enunciate the following theorems:—

If wrenches upon the three screws A, B, C be applied to any rigid body, then these wrenches will equilibrate, provided that the intensity of each is proportional to the opposite side of the triangle.

If twist velocities about the three screws A, B, C animate a rigid body, then these twist velocities will neutralize if they are respectively proportional to the opposite sides of the triangle.

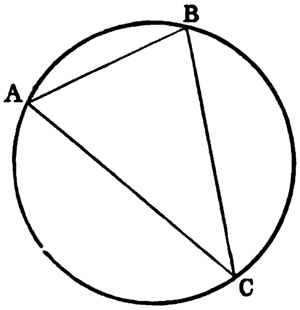

Fig. 4.

§ 7. **Decomposition of Twists and Wrenches.**—The theorems we have just enunciated lead to simple rules for effecting the composition, or the decomposition of twists or of wrenches. Let a twist on a screw X be given, and let it be required to find the components of this twist on any two given screws A, B, all three, of course, lying on the same cylindroid. Let ω be the amplitude of the twist on X. Then, by the last article, the following triad of twists on the screws X, A, B, respectively, will neutralize:—

$$\omega, \quad \omega\frac{BX}{AB}, \quad \omega\frac{AX}{AB},$$

whence the components on A and B of the twist about X are, so far as magnitudes and not signs are concerned,

$$\omega\frac{BX}{AB} \text{ and } \omega\frac{AX}{AB}.$$

A similar proposition holds for wrenches.

§ 8. **Composition of Twists and Wrenches.**—Let two twists, of amplitudes α and β, about the screws A and B, respectively, be applied to a rigid body. It is required to find the single resultant screw X, and the amplitude ω

of the resulting twist. Divide AB (fig. 5) in the point I, so that the segments AI and BI shall be in the inverse ratio of α to β. Bisect the arc AB at H, and draw HI, which will cut the circle in the required point X.

The value of ω is obtained from the equations,

$$\frac{\omega}{AB} = \frac{\alpha}{BX} = \frac{\beta}{AX}.$$

If the amplitudes α and β had opposite signs, then we should have taken for I the point dividing AB externally in the given ratio.

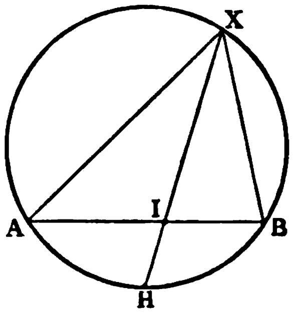

Fig. 5.

§ 9. **Screw Co-ordinates.**—We have developed, in the *Theory of Screws*, Chap. IV., the conception of Screw Co-ordinates. In the case of the cylindroid, the co-ordinates of any screw X, with respect to two standard screws A and B, are found by resolving a wrench of unit intensity on X into its two components on A and B. These components are said to be the co-ordinates of the screw. If we denote the co-ordinates of X by X_1 and X_2, we have

$$X_1 = \frac{BX}{AB}; \quad X_2 = \frac{AX}{AB}.$$

The co-ordinates satisfy the identical relation,

$$X_1^2 - 2X_1 X_2 \cos \epsilon + X_2^2 = 1,$$

where ϵ denotes the angle between the two screws of reference, that is, the angle subtended by the chord AB.

§ 10. **Reciprocal Screws.**—Perhaps the most striking relation between a pair of screws is exhibited when the two screws are *reciprocal.* The theory of reciprocal screws is of so much importance in Dynamics, that it becomes of interest to see what aspect it will assume in the circular representation. We might, indeed, anticipate that a relation of so much significance ought to be presented in a characteristic form, if the circular representation be a natural epitome of the theory. This anticipation is realized.

Two screws are reciprocal if a wrench on either does no work when a rigid body is twisted about the other. Every screw A on the cylindroid has one other reciprocal screw B lying also on the cylindroid. Denoting A and B by their corresponding points on the circle, we may enunciate the following theorem:—

The chord joining a pair of reciprocal screws passes through the pole of the axis of pitch.

We have shown (*Theory of Screws*, p. 21), that the condition that two screws shall be reciprocal is thus expressed:—

$$(p_\alpha + p_\beta) \cos \theta - d \sin \theta = 0,$$

where p_α and p_β are the pitches, where θ is the angle between the two screws, and d their shortest distance. We shall show that this condition is fulfilled, for any two screws A and B (fig. 6), whose chord passes through O, the pole of the axis of pitch PQ.

Since $SO \cdot ST = SA^2 = SB^2$, we have $\angle STA = \angle SAB$, and $\angle STB = \angle SBA$, whence $\angle ATB$ is bisected by ST, and therefore

$$\angle ATP = \tfrac{1}{2} \angle ASB = \theta = \angle BTQ.$$

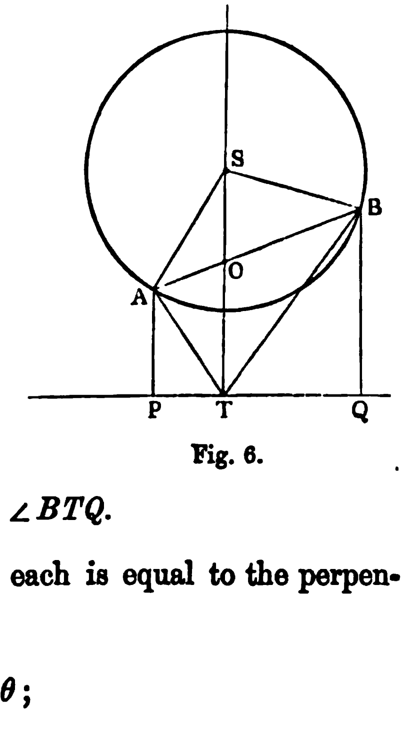

Fig. 6.

It follows that $AP \cos \theta = PT \sin \theta$, since each is equal to the perpendicular from P on AT.

Similarly,

$$BQ \cos \theta = QT \sin \theta;$$

whence $$(AP + BQ) \cos \theta - (PT + QT) \sin \theta = 0,$$

which, from §§ 4 and 5, reduces to

$$(p_\alpha + p_\beta) \cos \theta - d \sin \theta = 0.$$

The theorem has thus been proved.

We have, therefore, a very simple construction for finding the screw B

reciprocal to a given screw A. It is only necessary to join A to O, the pole of the axis of pitch, and the point in which this cuts the circle again gives B the required reciprocal screw.

We also notice that the two principal screws of the cylindroid are reciprocal, inasmuch as their chord contains O.

§ 11. **Another Geometrical Representation of the Pitch.**—We can obtain another geometrical expression for the pitch, which will be often more convenient than the perpendicular distance from the point to the axis of pitch.

Let A (fig. 7) be the point of which the pitch is required. Join AOB, let fall AP perpendicular on the axis of pitch PT, and produce AP to intersect BT at E. Then, since O is the pole of PT, the line PT bisects the angle ATE, and therefore AE must be bisected at P.

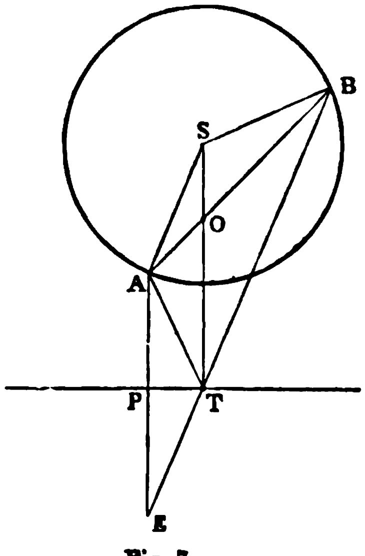

Fig. 7.

From similar triangles,

$$OB : AB :: OT : AE;$$

whence, if p_a be the pitch of A, and, of course, equal to AP, or $\frac{1}{2} AE$,

$$2p_a = \frac{AB \,.\, OT}{OB}.$$

But since the quadrilateral $ASBT$ is inscribable in a circle,

$$OT \,.\, OS = OA \,.\, OB;$$

whence, eliminating OT, we have, finally,

$$p_a = \frac{AO \,.\, AB}{2OS}:$$

as OS is constant, we see that p_a varies as $AO \,.\, AB$, whence the following theorem:—

If AB be any chord passing through O, the pole of the axis of pitch, then the pitch of the screw A is proportional to the product AO . AB.

§ 12. **Pitches of Reciprocal Screws.**—It is known that the sum of the reciprocals of the pitches of a pair of reciprocal screws on the cylindroid is constant. This is obvious from the geometrical representation. For, since the triangles APT and BQT (fig. 6) are similar, we have

$$AP : BQ :: TP : TQ :: OA : OB;$$

whence O is the centre of gravity of particles of masses $\frac{1}{p_\alpha}$ and $\frac{1}{p_\beta}$ placed at A and B, respectively.

From the known property of the centre of gravity,

$$AP\frac{1}{p_\alpha} + BQ\frac{1}{p_\beta} = OT.\left(\frac{1}{p_\alpha} + \frac{1}{p_\beta}\right);$$

but each of the terms on the left-hand side is unity, whence, as required,

$$\frac{1}{p_\alpha} + \frac{1}{p_\beta} = \frac{2}{OT}.$$

The second mode of representing the pitch also proves this theorem For since

$$p_\alpha = \frac{AO . AB}{2OS},$$

$$p_\beta = \frac{BO . BA}{2OS};$$

we have

$$p_\alpha + p_\beta = \frac{AB^2}{2OS}; \quad p_\alpha p_\beta = \frac{AB^2 . AO . BO}{4OS^2},$$

from which

$$\frac{1}{p_\alpha} + \frac{1}{p_\beta} = \frac{2 . OS}{OA . OB};$$

but $OA . OB$ is constant for every chord through O; and, as OS is constant, it follows that the sum of the reciprocals of the pitches must be constant.

§ 13. **The Virtual Coefficient.**—The function so designated is an important one in the Theory of Screws. It may be defined to be one-half of the expression

$$(p_\alpha + p_\beta)\cos\theta - d\sin\theta.$$

We have already seen that the evanescence of this function expresses that the two screws are reciprocal. In general this function possesses qualities which are analogous to those of the cosine of the angle between two rays. We shall obtain a geometrical expression.

Let A and B (fig. 8) be the two screws. Let, as usual, O be the pole of the axis of pitch PT, and let $P'T'$ be the polar of O'. From T let fall the perpendicular TF upon AT', and from O let fall the perpendicular OG upon AB.

As before, we have $\angle AT'P' = \angle T'TF = \theta$; also, since $\angle SAO' = \angle AT'O'$, and $\angle SAO = \angle ATO$, we must have

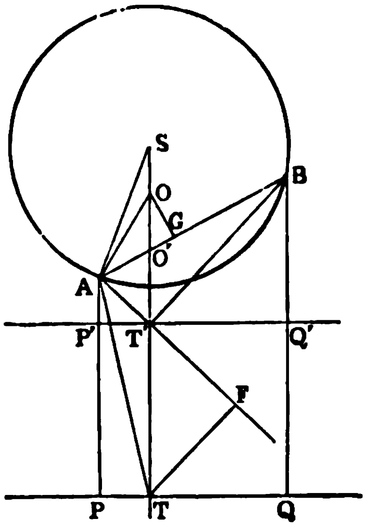

Fig. 8.

$$\angle SAO' - \angle SAO = \angle AT'O' - \angle ATO, \quad \text{or} \quad \angle OAG = \angle TAF;$$

whence the triangles OAG and TAF are similar, and, consequently,

$$TF = OG . \frac{AT}{AO} = OG . \frac{AS}{OS};$$

but, as in § 10, we have

$$(p_\alpha - TT' + p_\beta - TT')\cos\theta - d\sin\theta = 0;$$

whence the virtual coefficient is simply,

$$TT' \cos\theta = OG\,\frac{AS}{OS},$$

and we have the following theorem:—

The virtual coefficient of any pair of screws varies as the perpendicular distance of their chord from the pole of the axis of pitch.

We also notice that the line *TF* expresses the actual value of the virtual coefficient.

The theorem of course includes, as a particular case, the property of reciprocal screws, which states that their chord passes through the pole of the pitch axis.

§ 14. **Another Investigation of the Value of the Virtual Coefficient.**—It will be instructive to investigate the theorem of the last article by a different part of the theory. We shall commence with a proposition in elementary geometry.

Let *ABC* (fig. 9) be a triangle circumscribed by a circle, the lengths of the sides being, as usual, *a*, *b*, *c*. Draw tangents at *A*, *B*, *C*, and thus form the triangle *XYZ*. It can be readily shown that if masses a^2, b^2, c^2 be placed at *A*, *B*, *C*, their centre of gravity must lie on the three lines *AX*, *BY*, *CZ*. These lines must therefore be concurrent at *I*, which is the centre of gravity.

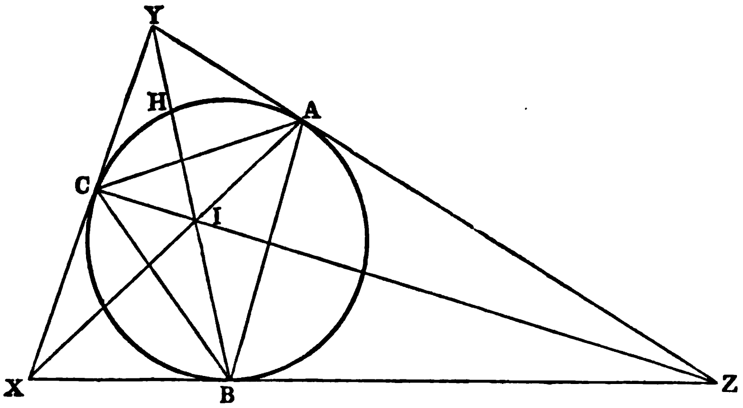

Fig. 9.

Let *BY* intersect the circle again at *H*. Then, since *AC* is the polar of *Y*, the arc *AC* is divided harmonically at *H* and *B*; consequently the four points *A*, *C*, *B*, *H* subtend an harmonic pencil at any point on the circle. Let that point be *B*, then *BC*, *BI*, *BA*, *BZ* form a harmonic pencil; hence *CZ* is cut harmonically, and consequently *Z* must be the centre of gravity of particles, + a^2 at *A*, + b^2 at *B*, and − c^2 at *C*.

Suppose the axis of pitch to be drawn (it is not shown in the figure), and let h be the perpendicular let fall from Z on this axis, also let p_1, p_2, p_3 be the pitches of the screws A, B, C.

Then, by a familiar property of the centre of gravity, we must have

$$p_1a^2 + p_2b^2 - p_3c^2 = (a^2 + b^2 - c^2)\, h = 2abh \cos C.$$

We shall take A, B as the two screws of reference, and if ρ_1 and ρ_2 be the co-ordinates of C with respect to A and B; then, from the principles of screw co-ordinates (*Theory of Screws*, p. 31), we have

$$p_3 = p_1\rho_1^2 + p_2\rho_2^2 + 2\varpi_{12}\rho_1\rho_2,$$

where ϖ_{12} is the virtual coefficient of A and B. In the present case we have

$$\rho_1 = \frac{a}{c}; \quad \rho_2 = \frac{b}{c};$$

whence,

$$p_1a_2^2 + p_2b^2 - p_3c^2 + 2\varpi_{12}\, ab = 0;$$

and, finally,

$$\varpi_{12} = - h \cos C.$$

The negative sign has no significance for our present purpose, and hence we have the following theorem :—

The virtual coefficient of two screws is equal to the cosine of the angle subtended by their chord, multiplied into the perpendicular from the pole of the chord on the axis of pitch.

This is, perhaps, the most concise geometrical expression for the virtual coefficient. It vanishes if the perpendicular becomes zero, for then the chord must pass through the pole of the pitch axis, and the two screws be reciprocal. The cosine enters the expression in order that its evanescence, when $P = 90$, may provide for the circumstance that the perpendicular is then infinite.

This result is easily shown to be equivalent to that of the last article by the following theorem :—

If any two chords be drawn in a circle, then the cosine of the angle subtended by the first chord, multiplied into the perpendicular distance from its pole to the second chord, is equal to the cosine of the angle subtended by the second chord, multiplied into the perpendicular from its pole to the first chord.

It follows that the virtual coefficient must be equal to the perpendicular from the pole of the axis of pitch upon the chord joining the two screws, multiplied into the cosine of the angle in the arc cut off by the axis of pitch. This is the expression of § 13, namely,

$$OG\,\frac{AS}{OS}.$$

§ 15. **Application of Screw Co-ordinates.**—It will be useful to show how the geometrical form for the virtual coefficient is derived from the theory of screw co-ordinates. Let α_1, α_2, and β_1, β_2 be the co-ordinates of two screws on the cylindroid; then, if the screws of reference be reciprocal, the virtual coefficient is (*Theory of Screws*, p. 35),

$$p_1\alpha_1\beta_1 + p_2\alpha_2\beta_2.$$

Let A, B (fig. 10) be the screws of reference, and let C and C' be the two screws of which the virtual coefficient is required. Let PQ be the axis of pitch of which O is the pole, then O lies on AB, as the two screws of reference are reciprocal.

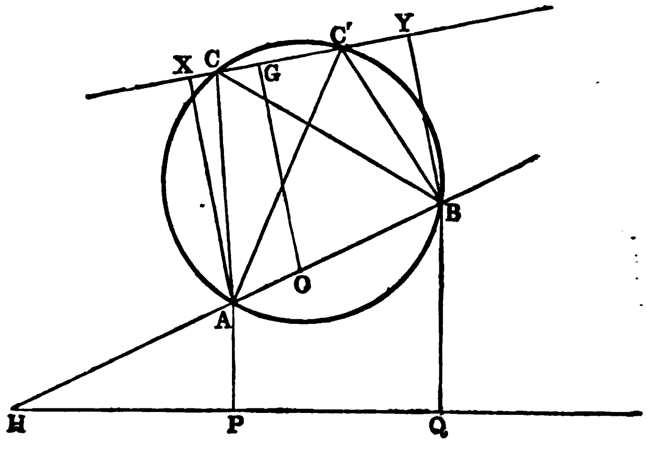

Fig. 10.

As AB is divided harmonically at O and H, we have

$$OA : OB :: HA : HB :: AP : BQ :: p_1 : p_2;$$

whence O is the centre of gravity of masses $\frac{1}{p_1}$, $\frac{1}{p_2}$ at A and B, respectively. If, therefore, AX, BY, OG be perpendiculars on CC', we have, from the principle of the centre of gravity,

$$\frac{1}{p_1} AX + \frac{1}{p_2} BY = \left(\frac{1}{p_1} + \frac{1}{p_2}\right) OG,$$

or,

$$p_2 AX + p_1 BY = (p_1 + p_2)\, OG;$$

but, by a well-known property of the circle, if m be the radius,

$$2m AX = AC \,.\, AC'; \quad 2m BY = BC \,.\, BC';$$

whence,

$$p_1 BC \,.\, BC' + p_2 AC \,.\, AC' = 2m(p_1 + p_2)\, OG = m \frac{OG \,.\, AB^2}{OS} \quad (\S\ 12),$$

or,

$$p_1 \frac{BC}{AB} \cdot \frac{BC'}{AB} + p_2 \frac{AC}{AB} \cdot \frac{AC'}{AB} = m \frac{OG}{OS}.$$

But, from the expressions for screw co-ordinates (§ 9), this reduces to

$$p_1 \alpha_1 \beta_1 + p_2 \alpha_2 \beta_2 = m \frac{OG}{OS}.$$

The required expression has thus been demonstrated.

§ 16. **Properties of the Virtual Coefficient.**—If the virtual coefficient be given, then the chord envelops a circle with its centre at the pole of the axis of pitch. Two screws can generally be found which have a given virtual coefficient with a given screw. If one screw be given, the screw which has the greatest virtual coefficient is found when the chord is perpendicular to the line joining the given screw to the pole of the axis of pitch.

Let A (fig. 11) be a given screw, and X a variable screw; then their virtual coefficient is proportional to OG, that is, to the sine of A, that is, to the length BX. Thus, as X varies round the circle, its virtual coefficient with the fixed screw A varies proportionally to the distance of X from the fixed point B.

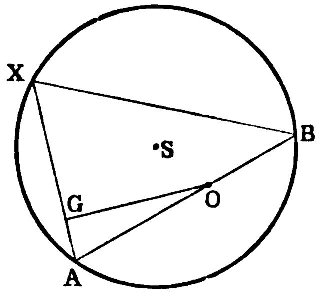

Fig. 11.

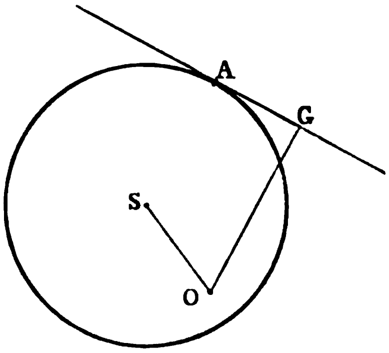

Fig. 12.

§ 17. **Another Construction for the Pitch.**—As the virtual coefficient of two coincident screws is equal to their pitch, we shall obtain another geometrical construction for the pitch by supposing two screws to coalesce. For (in fig. 12), let A be the chord joining the two coincident screws that is the tangent, then, from § 13, we have for the pitch,

$$m\,\frac{OG}{OS},$$

whence the following theorem:—

The pitch of any screw is proportional to the perpendicular on the tangent at the point let fall from the pole of the axis of pitch.

§ 18. **Another Proof of the Geometrical Expression for the Virtual Coefficient.**—We are now able to give an instantaneous proof of the theorem otherwise shown in §§ 13, 14, 15. If the two screws of reference be reciprocal, and if ρ_1 and ρ_2 be the co-ordinates of another screw, then it is known, from the theory of co-ordinates, that the virtual coefficients of this screw, with respect to the screws of reference, are $p_1\rho_1$ and $p_2\rho_2$, respectively (*Theory of Screws*, p. 35).

Thus (fig. 11), the virtual coefficient of X and A must be (§ 9),

$$p_1 \frac{BX}{AB};$$

but we know (§ 11),

$$p_1 = \frac{AO.AB}{2SO};$$

whence the virtual coefficient is

$$\frac{AO.BX}{2SO} = \frac{2m \sin A.AO}{2SO} = m\frac{OG}{OS},$$

as already determined. This is an instructive proof, besides being much shorter than the other methods.

§ 19. **Screws of Zero Pitch.**—A screw of zero pitch is reciprocal to itself. The tangent to a screw of zero pitch, inasmuch as it is the chord joining two reciprocal screws, must pass through the pole of the pitch line. This is, of course, the same thing as to say that the pitch line intersects the circle in two screws, each of which has zero pitch.

§ 20. **Consideration of a Special Case.**—We have, throughout this Paper, as in the *Theory of Screws* generally, referred only to the most general case of freedom of the second order. The circular representation, however, suggests one particular case which seems to have sufficient interest to demand a word of notice.

We have supposed that the axis of pitch occupies any arbitrary position. Let us now assume that it is a tangent to the representative circle. This really involves only a very slight specialization of the general case. It could be produced by augmenting the pitches of all the screws on the cylindroid, by such a constant as shall make one of the two principal screws have zero pitch.

The following properties of the screws are then obvious:—

1. There is only one screw of zero pitch, O.
2. The pitches of all the other screws have the same sign.
3. The maximum pitch is double the radius.

4. The screw O is reciprocal to every screw on the surface, and this is the only case in which a screw on the cylindroid is reciprocal to every other screw thereon.

We here illustrate a somewhat peculiar condition of the general theory of Reciprocal Screw systems. The general theory supposes that k screws determine one system, while $6-k$ reciprocal screws determine the reciprocal system. Every screw of either system is reciprocal to every screw of the other. The special case arises when one screw is found to be common to the two reciprocal systems; of course, as this screw must be reciprocal to itself, its pitch has to be zero.

§ 21. **The Kinetic Energy of Twisting Motion.**—Up to the present point of this Memoir we have been engaged with those parts of the theory which only involve the principles of Statics and Kinematics. We are now to show how the *kinetical* parts of the Theory of Screws can be studied and illustrated by the representative circle. It will be found that the geometrical theory of the circle lends itself with singular appropriateness to the elucidation of the theories of impulsive forces and of small oscillations.

We have studied (*Theory of Screws*, p. 55) the important parameter, which is expressed as u_θ, appropriate to each screw θ. This quantity is a linear magnitude, like the pitch; but, unlike the pitch, which is of course quite independent of the body twisted, the parameter u_θ depends on the mass and the position of the body. The significance of this parameter is best expressed by the following definition:—

If a rigid body of mass M twist about a screw θ, with the twist velocity $\dot{\theta}$, then the kinetic energy of the body may be written in the form

$$Mu_\theta^2\dot{\theta}^2,$$

where u_θ is a linear magnitude appropriate to the screw θ.

The function u_θ^2 is the arithmetic mean between the square of the radius of gyration and the square of the pitch. This is thus proved:—

Let $\eta_1, \ldots \eta_6$ be the co-ordinates of a screw of zero pitch on the same axis as θ, reference being made to the absolute principal screws of inertia (*Theory of Screws*, p. 100), then the co-ordinates of θ are

$$\eta_1 + \frac{p_\theta}{4p_1}\cdot\frac{dR}{d\eta_1}, \; \ldots \; \eta_6 + \frac{p_\theta}{4p_6}\cdot\frac{dR}{d\eta_6}.$$

Substituting these values in the general expression for u_θ^2 (*Theory of Screws*, p. 55),

$$p_1^2\theta_1^2 + \ldots + p_6^2\theta_6^2,$$

we obtain

$$u_\theta^2 = u_\eta^2 + \frac{1}{2}p_\theta . \Sigma p_1\eta_1 . \frac{dR}{d\eta_1} + \frac{1}{16}p_\theta^2\Sigma\left(\frac{dR}{d\eta_1}\right)^2;$$

but as shown (*loc. cit.*, p. 114),

$$\Sigma p_1\eta_1\frac{dR}{d\eta_1} = 0, \quad \Sigma\left(\frac{dR}{d\eta_1}\right)^2 = 8;$$

and if ρ_θ be the radius of gyration,

$$u_\eta^2 = \tfrac{1}{4}\rho_\theta^2,$$

whence, finally,

$$u_\theta^2 = \tfrac{1}{4}(\rho_\theta^2 + p_\theta^2),$$

which proves the theorem.

This result might have been obtained in a more simple manner, as follows:—

The kinetic energy of the body when twisting about θ may be regarded as the sum of two parts: one, the kinetic energy of the rotation; the other, of the translation. As the motion of each point of the body by the rotation is perpendicular to that of the translation, the total kinetic energy will be obtained by adding these two parts. The energy of the rotation is simply

$$\tfrac{1}{2}M\rho_\theta^2\dot{\theta}_2,$$

this being in accordance with the definition of the radius of gyration ρ_θ. The kinetic energy due to the translation is, of course,

$$\tfrac{1}{2}Mp_\theta^2\dot{\theta}^2,$$

whence the total kinetic energy is

$$\tfrac{1}{2}M\dot{\theta}^2(\rho_\theta^2 + p_\theta^2),$$

and therefore, as before,

$$u_\theta^2 = \tfrac{1}{2}(\rho_\theta^2 + p_\theta^2).$$

In the case where θ is one of the principal screws of inertia,

$$\rho_\theta^2 = p_\theta^2 = u_\theta^2.$$

We shall now examine the law of distribution of u_θ upon the several screws of the cylindroid. The representative circle will give a ready geometrical construction.

Let θ_1 and θ_2 be the two co-ordinates of θ relatively to any two screws of reference on the cylindroid. Then the components of the twist velocity will be $\dot{\theta}\theta_1$ and $\dot{\theta}\theta_2$. The actual velocity of any point of the body will necessarily be a linear function of these components. The square of the velocity will contain terms in which $\dot{\theta}^2$ is multiplied into θ_1^2, $\theta_1\theta_2$, θ_2^2, respectively. If, then, by integration we obtain the total kinetic energy, it must assume the form

$$M\dot{\theta}^2(\lambda\theta_1^2 + 2\mu\theta_1\theta_2 + \nu\theta_2^2),$$

whence, from the definition of u_θ,

$$u_\theta^2 = \lambda\theta_1^2 + 2\mu\theta_1\theta_2 + \nu\theta_2^2.$$

The three constants, λ, μ, ν, are the same for all screws on the cylindroid. They are determined by the material disposition of the body relatively to the surface.

We have chosen the two screws of reference arbitrarily, but this equation will receive a remarkable simplification when the two screws of reference have been chosen with special appropriateness.

Let BX and AX (fig. 13) be denoted respectively by ρ_1 and ρ_2, and if ϵ denote the angle subtended by AB, we have (from § 9),

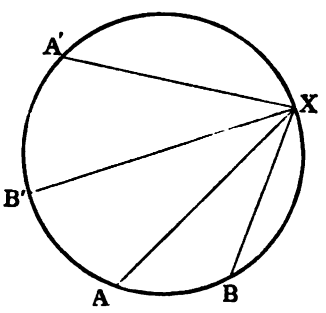

Fig. 13.

$$\lambda\rho_1^2 + 2\mu\rho_1\rho_2 + \nu\rho_2^2 - u_\theta^2(\rho_1^2 - 2\rho_1\rho_2\cos\epsilon + \rho_2^2) = 0.$$

Let us now transform this equation from the screws of reference A, B to another pair of screws A', B'. Let ρ_1', ρ_2' be the distances of X from A', B', respectively; then, from Ptolemy's theorem, we have the following equations:—

$$\rho_1 . A'B' = \rho_2' . AA' - \rho_1' . AB'.$$

$$\rho_2 . A'B' = \rho_2' . A'B - \rho_1' . BB',$$

We thus see that ρ_1 and ρ_2 are linear functions of ρ_1' and ρ_2', the several coefficients $A'B'$, $A'B$, &c., in these two equations being constant. The equation for u_θ^2 is thus to be transformed by a linear substitution for ρ_1 and ρ_2. Of course u_θ, being dependent only upon the position of X, is quite unaffected by the change of the screws of reference. We can therefore apply the well-known principle that the invariant of this binary quantic can only differ by a constant factor from the transformed value. The invariant is

$$(\lambda - u_\theta^2)(\nu - u_\theta^2) - (\mu + u_\theta^2 \cos\epsilon)^2.$$

This must be true for *every* point X, and therefore for all values of u_θ^2. It is necessary that the coefficients of the terms in the expression

$$u_\theta^4 \sin^2\epsilon - u_\theta^2(\lambda + \nu + 2\mu \cos\epsilon) + \lambda\nu - \mu^2$$

shall be severally proportional to those in the transformed expression

$$u_\theta^4 \sin^2\epsilon' - u_\theta^2(\lambda' + \nu' + 2\mu' \cos\epsilon') + \lambda'\nu' - \mu'^2.$$

We thus obtain the two equations of condition,

$$\frac{\sin^2\epsilon'}{\sin^2\epsilon} = \frac{\lambda' + \nu' + 2\mu' \cos\epsilon'}{\lambda + \nu + 2\mu \cos\epsilon} = \frac{\lambda'\nu' - \mu'^2}{\lambda\nu - \mu^2}.$$

The four quantities, λ', μ', ν', ϵ', may now be chosen arbitrarily, subject to these two equations, which are the necessary as well as the sufficient conditions. Indeed it is obvious that there must be but two independent quantities corresponding to the two positions of A' and B'.

We may impose two conditions on the four quantities, and for our present purpose we shall make

$$\lambda' = \nu'; \qquad \mu' = 0,$$

The equations of λ' and ϵ' are then

$$\frac{\sin^2\epsilon'}{\sin^2\epsilon} = \frac{2\lambda'}{\lambda + 2\mu\cos\epsilon + \nu} = \frac{\lambda'^2}{\lambda\nu - \mu^2},$$

and we obtain,

$$\lambda' = \frac{2(\lambda\nu - \mu^2)}{\lambda + 2\mu\cos\epsilon + \nu},$$

$$\sin^2\epsilon' = \sin^2\epsilon\,\frac{4(\lambda\nu - \mu^2)}{(\lambda + 2\mu\cos\epsilon + \nu)^2};$$

λ' is thus uniquely determined, and the expression for $\sin^2\epsilon'$ gives for ϵ' four values of the type $\pm\epsilon'$, $\pm(\pi - \epsilon')$. The negative values are meaningless, and the two others are coincident, because the arc which subtends ϵ' on one side subtends $\pi - \epsilon'$ on the other.

There is thus a single pair of screws of reference which permit the expression for u_θ^2 to be exhibited in the canonical form

$$c^2u_\theta^2 = \lambda'(\rho_1^2 + \rho_2^2).$$

We are now led to a simple geometrical representation for u_θ^2. Let A, B (fig. 14) be the two canonical screws of reference. Bisect AB in O', then

$$\begin{aligned}\rho_1^2 + \rho_2^2 &= BX^2 + AX^2,\\ &= 2AO'^2 + 2XO'^2,\\ &= 2XO'.YO' + 2XO'^2,\\ &= 2XY.XO'.\end{aligned}$$

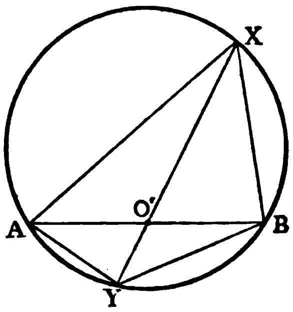

Fig. 14.

It is obvious that the point O' must have a critical importance in the kinetic theory, and its fundamental property, which has just been proved, is expressed in the following theorem:—

If a rigid body be twisting with the unit of twist velocity about any screw X on the cylindroid, then its kinetic energy is proportional to the rectangle XO', XY, where O' is a fixed point on the chord XY.

We are at once reminded of the theorem of § 11, in which a precisely similar law is found for the distribution of pitch, only in this case another point, O, is used instead of the point O'. These two points, O and O', are both of great utility in the representative circle. From their analogy we obtain the following theorem, in which we call the polar of O' the *axis of inertia*:—

If a rigid body be twisting with the unit of twist velocity about X, then its kinetic energy is proportional to the perpendicular distance from X to the axis of inertia.

The geometrical construction for the pitch given in § 14 can also be applied to determine u_θ^2. This quantity is therefore proportional to the perpendicular from O' on the tangent at X.

It thus appears that the representative circle presents a vivid picture of the law of distribution of u_θ^2. The axis of inertia cannot cut the representative circle in real points, for otherwise we should have a twist velocity without any kinetic energy. There is no similar restriction to the axis of pitch. We thus see that O' must always lie inside the circle, but that O may be in any part of the plane.

§ 22. **Conjugate Screws of Inertia.**—We have made much use, in the *Theory of Screws*, of the conception of Conjugate Screws of Inertia. We shall here approach the subject in a different manner from that employed in the work referred to.

Let α be a screw about which a rigid body is twisting with a twist velocity $\dot{\alpha}$; let the body be simultaneously animated by a twist velocity $\dot{\beta}$ about a screw β. These two will compound into a twist velocity $\dot{\theta}$ about some screw θ. If the body only had the first twist velocity, its kinetic energy would be $Mu_\alpha^2\dot{\alpha}^2$. If it only had the second, the energy would be $Mu_\beta^2\dot{\beta}^2$. When it has both twist velocities together, the kinetic energy is $Mu_\theta^2\dot{\theta}^2$. Generally it will not be true that the resulting kinetic energy is equal to the sum of the components; but, under a special relation between α and β, we can have this equality; and when this is the case, then α and β are said to be *conjugate screws of inertia*. The necessary condition is thus expressed:—

$$u_\theta^2\,\dot{\theta}^2 = u_\alpha^2\,\dot{\alpha}^2 + u_\beta^2\,\dot{\beta}^2.$$

We have now to prove the following important theorem :—

Any chord through the pole of the axis of inertia intersects the circle in a pair of conjugate screws of inertia.

For we have,

$$\dot{\theta}^2 : \dot{\alpha}^2 : \dot{\beta}^2 :: AB^2 : BX^2 : AX^2;$$

but if AB passes through the pole of the axis of inertia, then the centre of gravity of masses $-AB^2$ at X, $+BX^2$ at A, and $+AX^2$ at B, will lie on the axis of inertia; and, accordingly,

$$AB^2 u_\theta^2 = BX^2 u_\alpha^2 + AX^2 u_\beta^2;$$

whence,

$$\dot{\theta}^2 u_\theta^2 = \dot{\alpha}^2 u_\alpha^2 + \dot{\beta}^2 u_\beta^2,$$

which proves the theorem.

Or we might have proceeded thus :—From Ptolemy's theorem (fig. 14),

$$AB . XY = AX . BY + AY . BX :$$

multiplying by $AB . XO'$,

$$AB^2 . XY . XO' = AX . AB . BY . XO' + AY . XO' . BX . AB;$$

but, from the property of the circle,

$$BY . XO' = AX . BO'; \quad AY . XO' = BX . AO';$$

whence

$$AB^2 . XY . XO' = AX^2 . AB . BO' + BX^2 . AB . AO',$$

from which we obtain, as before,

$$\dot{\theta}^2 u_\theta^2 = \dot{\alpha}^2 u_\alpha^2 + \dot{\beta}^2 u_\beta^2.$$

§ 23. **Impulsive Screws and Instantaneous Screws.**—A rigid body having two degrees of freedom lies initially at rest. It is suddenly acted upon by an impulsive wrench of large intensity acting for a short time. The body will, in general, commence to move by twisting about some screw on the cylindroid, and the kinetic problem now to be studied is the following :—Given the impulsive screw, and the intensity of the impulsive wrench, find the instantaneous screw and the acquired twist velocity.

The problem will be rendered more concise by the conception of the reduced wrench (*Theory of Screws*, p. 60). It is to be remembered, that as the body is only partially free, there are an infinite number of screws on which wrenches would make the body commence to twist about a given screw on the cylindroid. For, let θ be an impulsive screw situated anywhere, and let an impulsive wrench on θ cause the body to commence to move by twisting about some screw, α, on the cylindroid. Let λ, μ, ν, ρ be any four screws reciprocal to the cylindroid. Then any wrench on a screw belonging to the system defined by these five screws will make the body commence to move by twisting about α. Let ϵ be that one screw on the cylindroid which is reciprocal to θ, then ϵ is reciprocal to the whole system defined by λ, μ, ν, ρ, θ, and, conversely, each screw of this system will be reciprocal to ϵ. We thus see that any screw, wherever situated, provided only that it is reciprocal to ϵ, will be an impulsive screw corresponding to α as an instantaneous screw. Any one of this system may, with perfect generality, be chosen as the impulsive screw. Among them there is one which has a special feature. It is that screw, ϕ, on the cylindroid which is reciprocal to η; and hence we have the following theorem :—

Given any screw, α, on the cylindroid, then there is another screw, ϕ, also on the cylindroid, such, that an impulsive wrench administered on ϕ will make the body twist about α.

This correspondence of the two systems of screws must be of the one-to-one type; for, suppose that two impulsive screws on the cylindroid had the same instantaneous screw, it would then be possible for two impulsive wrenches, of properly chosen intensities on two different screws, to produce equal and opposite twist velocities on the common instantaneous screw. The body would then not move, and therefore the two impulsive wrenches must equilibrate. But this is impossible, for they are on two different screws.

§ 24. **The Homographic Systems.**—From what has been shown it might be expected that the points corresponding to the instantaneous screws and those corresponding to the impulsive screws should, on the representative circle, form two homographic systems. That this is so we shall now prove.

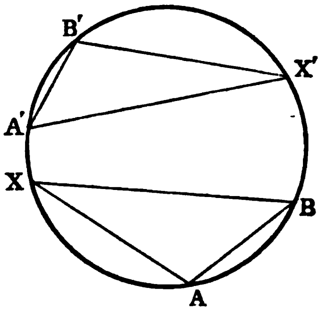

Fig. 15.

Let A, B (fig. 15) be a pair of impulsive screws, and let A', B' be respectively the corresponding pair of instantaneous screws, *i. e.* an impulsive wrench on A will make the body commence to twist about A', and similarly for B and B'. Let an impulsive wrench on A, of unit intensity, generate a twist velocity, α, about A', and let β be the similar quantity for B and B'.

Let X be any other screw on which an impulsive wrench is to be applied to the body supposed quiescent. The body will commence to twist about some other screw, X', with a certain twist velocity ω. We can determine ω in the following manner:—The unit impulsive wrench on X can be replaced by two component wrenches on A and B, the intensities of these being

$$\frac{BX}{AB},\quad \frac{AX}{AB},$$

respectively.

These impulsive wrenches will severally generate twist velocities about A', B' of the value,

$$\alpha\frac{BX}{AB},\quad \beta\frac{AX}{AB}:$$

these components must, when compounded, produce the twist velocity ω about X', and, accordingly, we have

$$\alpha\frac{BX}{AB}=\omega\frac{B'X'}{A'B'};\quad \beta\frac{AX}{AB}=\omega\frac{A'X'}{A'B'}.$$

Retaining A, B, A', B', as before, let us now introduce a second pair of points, Y and Y', instead of X and X', and writing ω' instead of ω, we have

$$\alpha\frac{BY}{AB}=\omega'\frac{B'Y'}{A'B'};\quad \beta\frac{AY}{AB}=\omega'\frac{A'Y'}{A'B'};$$

whence, eliminating α, β, ω, ω', we have

$$\frac{BX}{AX}:\frac{BY}{AY}::\frac{B'X'}{A'X'}:\frac{B'Y'}{A'Y'}.$$

As the length of a chord is proportional to the sine of the subtended angle, we see that the anharmonic ratio of the pencil, subtended by the four points, A, B, X, Y at a point on the circumference, is equal to that subtended by their four correspondents, A', B', X', Y'. We thus learn the following important theorem :—

A system of points on the representative circle, regarded as impulsive screws, and the corresponding system of instantaneous screws, form two homographic systems.

§ 25. **The Homographic Axis.**—Let A, B, C, D (fig. 16) represent four impulsive screws, and let A', B', C', D' be the four corresponding instantaneous screws. Then, by the well-known homographic properties of the circle, the three points, L, M, N, will be collinear, and we have the following theorem :—

If A and B be any two impulsive screws, and if A′ and B′ be the corresponding instantaneous screws, then the chords AB′ and BA′ will always intersect upon the fixed right line XY.

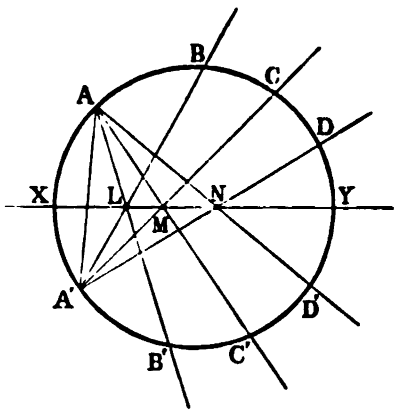

Fig. 16.

This right line is called the homographic axis. It intersects the circle in two points, X and Y, which are the double points of the homographic systems. These points enjoy a special dynamical significance. They are the two Principal Screws of Inertia, and hence—

The homographic axis intersects the circle in two points, each of which possesses the property, that an impulsive wrench administered on that screw will make the body commence to move by twisting about the same screw.

The method by which we have been conducted to the Principal Screws of Inertia shows how it comes that there are in general two, and only two, of these screws on the cylindroid. The homographic axis is often known as the Pascal line, and thus we have a dynamical significance for Pascal's theorem.

§ 26. **Determination of the Homographic Axis.**—It is one of the fundamental parts of the theory of screws, that the two principal screws of inertia must be reciprocal, and must also be conjugate screws of inertia (*Theory of Screws*, p. 50). The homographic axis must therefore comply with the conditions thus prescribed. We have already shown (§ 10) the condition that two screws be reciprocal, and (§ 22) the condition that two screws be conjugate screws of inertia, and, accordingly, we see—

1°. That the homographic axis must pass through O, the pole of the axis of pitch.

2°. That the homographic axis must pass through O', the pole of the axis of inertia.

The point O and O' have been already discussed, and thus we have, as the simplest construction for the homographic axis, the chord joining O and O'.

§ 27. **Construction for Instantaneous Screws.**—The points O and O' afford a simple construction for the instantaneous screw, corresponding to a given impulsive screw. The construction depends upon the following theorem (*Theory of Screws*, p. 48):—

If two conjugate screws of inertia be regarded as instantaneous screws, then the impulsive screw corresponding to either is reciprocal to the other.

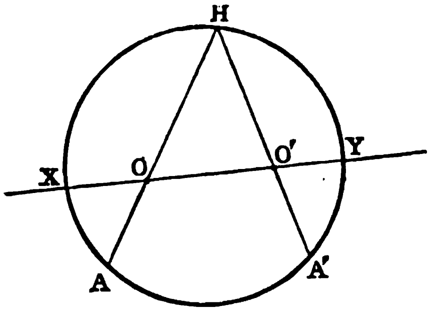

Fig. 17.

Let A be an impulsive screw (fig. 17); if we join AO we obtain H, the screw reciprocal to A; and if we join HO' we obtain A', the conjugate screw of inertia to H. Now, as A is the only screw reciprocal to H, it is necessary, by the theorem just given, that an impulsive wrench on A must make the body commence to move by twisting about A'.

As O and O' are fixed, it follows from a well-known geometrical theorem, that the corresponding positions of A and A' form two homographic systems.

§ 28. **Twist Velocity Acquired by an Impulse.**—We can obtain a geometrical expression for the twist velocity acquired about A' by a unit impulsive wrench on A. We have proved this theorem in one of the earlier Papers already referred to; but the following demonstration is simpler than that there given.

It appears, from the *Theory of Screws*, p. 56, that the twist velocity acquired on α by an impulsive wrench on η, is proportional to

$$\frac{\varpi_{\eta\alpha}}{u_\alpha^2},$$

the numerator being the virtual coefficient is proportional to $AO.A'H$ (fig. 17), and as u_α^2 is proportional to $A'O'.A'H$, we see that the required ratio varies as

$$\frac{AO}{A'O'} \infty \frac{HO'}{HO};$$

hence we obtain the following theorem:—

The impulsive wrench on A, of an intensity proportional to HO, generates a twist motion about A', with a velocity proportional to HO'.

The problem of the effect of impulsive forces is thus completely solved, both as regards the instantaneous screw, and the instantaneous twist velocity acquired.

§ 29. **Another Construction for the Unit Velocity.**—A still more concise method of determining the instantaneous screw can be obtained if we discard the points O and O', and introduce a new fixed point, Ω, also on the homographic axis.

Let X, Y (fig. 18) be the two principal screws of inertia. Let A be an impulsive screw, and A' the corresponding instantaneous screw. Draw through A the line AH parallel to XY. Join HA', and produce it to meet the homographic axis at Ω. Let α be the twist velocity generated by an

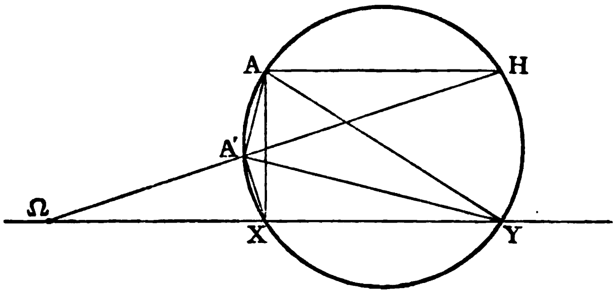

Fig. 18.

impulsive wrench of unit intensity at X, and let β be the corresponding quantity for y.

It may be easily shown that the triangle $AA'X$ is similar to $YA'\Omega$, and that the triangle $AA'Y$ is similar to $XA'\Omega$; whence we obtain,

$$\frac{A'X}{AX} = \frac{\Omega A'}{\Omega Y}; \quad \frac{A'Y}{AY} = \frac{\Omega A'}{\Omega X}.$$

The unit wrench on A decomposes into components on X and Y of respective intensities,

$$\frac{AY}{XY}, \quad \frac{AX}{XY}.$$

These will generate twist velocities,

$$\alpha \frac{AY}{XY}, \quad \beta \frac{AX}{XY}.$$

Let ω be the resulting twist velocity on A', then the components on X and Y must be equal to the quantities just written; whence,

$$\omega \frac{A'Y}{XY} = \alpha \frac{AY}{XY},$$

$$\omega \frac{A'X}{XY} = \beta \frac{AX}{XY},$$

and we obtain

$$\alpha = \omega \frac{\Omega A'}{\Omega X}; \quad \beta = \omega \frac{\Omega A'}{\Omega Y};$$

or,

$$\alpha : \beta :: \Omega Y : \Omega X;$$

we thus see that Ω is a fixed point wherever A and A' may be.

It also follows that

$$\omega \, . \, \Omega A'$$

is constant; whence we have the following theorem:—

Draw through the impulsive screw A a ray AH parallel to the homographic axis, then the ray from H to a fixed point Ω on the homographic axis will cut the circle in the instantaneous screw A', and the acquired twist velocity will be inversely proportional to $\Omega A'$.

If the twist velocity to be acquired by A' from a unit impulsive wrench on A be assigned, then $\Omega A'$ is determined: there will be two screws A', and two corresponding impulsive screws, either of which will solve the problem. The diameter through Ω finds the two screws about which the body will acquire the greatest and the least velocity with a given intensity for the impulsive wrench.

§ 30. **Twist Velocities on the Principal Screws.**—The quantities α and β, which are the twist velocities acquired by unit impulsive wrenches on the principal screws, can be expressed geometrically as follows (fig. 17):—

Let ω be the twist velocity acquired on A' by the wrench on A, then, by the last article,

$$AY\alpha = A'Y\omega,$$

$$AX\beta = A'X\omega;$$

whence

$$\alpha : \beta :: \frac{A'Y}{A'X} \cdot \frac{AY}{AX}.$$

This ratio is the anharmonic ratio of the four points X, Y, A, A', that is, of X, Y, O, O'; whence, finally,

$$\alpha : \beta :: \frac{O'Y}{O'X} : \frac{OY}{OX}.$$

§ 31. Another Investigation for the Twist Velocity acquired by an Impulse.

We have just seen that

$$\alpha AY = \omega A'Y,$$

$$\beta AX = \omega A'X;$$

whence

$$\alpha\beta AX . AY = \omega^2 A'X . A'Y.$$

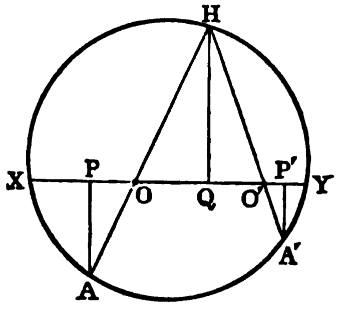

Fig. 19.

Let fall *AP*, *A′P′*, *HQ* perpendiculars on the homographic axis (fig. 19). Then, by the properties of the circle,

$$AX . AY : A'X . A'Y :: AP : A'P';$$

so that

$$\alpha\beta AP = \omega^2 A'P'.$$

By similar triangles,

$$\alpha\beta . \frac{AO}{OH} . HQ = \omega^2 \frac{O'A'}{O'H} . HQ;$$

whence,

$$\omega^2 = \alpha\beta \frac{OA . O'H}{O'A' . OH} \infty \frac{O'H^2}{OH^2};$$

or, as before (§ 28),

$$\omega \infty \frac{O'H}{OH}.$$

It will be noticed that, for this investigation, *H* may have been chosen *arbitrarily* on the circle. We thus see that, besides the two points *O* and *O′*, there will be a whole system of pairs of points which may be employed for finding the instantaneous screw, and for determining the instantaneous twist velocity.

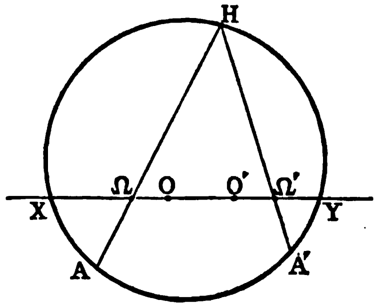

Fig. 20.

If we choose any two points (fig. 20), Ω and Ω′, so that

$$(X \Omega \Omega' Y) = (X O O' Y);$$

then *A* being given, *A*Ω finds *H*, and *H*Ω′ finds *A′*, while the acquired twist velocity is proportional to $\Omega' H \div \Omega H$. We can suppose Ω to go to infinity, and thus obtain the construction used in § 29. A similar construction is obtained when Ω' is at infinity.

The two points, A and A', will divide the arc cut off by XY in a constant anharmonic ratio, for the pencil $H\,(X\Omega\Omega' Y)$ always preserves the same anharmonic ratio as H moves round the circle.

§ 32. **A Curious Special Case.**—If η be an impulsive screw, and if α be the corresponding instantaneous screw, it will *not* usually happen that when α is the impulsive screw η is the corresponding instantaneous screw. If, however, in even a single case, it be true that the impulsive screw and the instantaneous screw are interchangeable, then the relation will be universally true.

Let Ω and Ω' (fig. 21) be a pair of points belonging to the system described in § 31. Then A being given, A' is found. If A' is similarly to find A, then the figure shows at once that Ω must lie on the polar of Ω', and, consequently, Ω and Ω' are conjugate points with respect to the circle; or, what comes to the same thing, they divide XY harmonically. The same must be true of each pair of points Ω and Ω', and therefore of O and O', and we have the following theorem:—

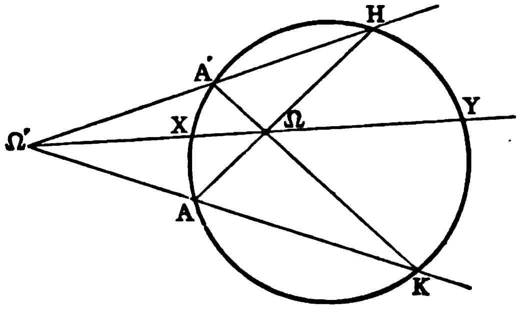

Fig. 21.

If the points O and O' be harmonic conjugates of the points where the homographic axis intersects the circle, then every pair of instantaneous and impulsive screws on the cylindroid are interchangeable.

We might, perhaps, speak of this condition of the system as one of *dynamical involution.* In this remarkable case an impulsive wrench of unit intensity applied to one of the principal screws of inertia will generate an equal and opposite velocity to that which would have been produced if the wrench had been applied to the other principal screw. The construction for the pairs of related screws becomes still more simplified by the theorem, that—

When the system is one of dynamical involution, the chord joining an impulsive screw with its instantaneous screw passes through the pole of the homographic axis.

We may take the opportunity of remarking, that dynamical involution is not confined to the system of the second order. It may be extended to a rigid body with any number of degrees of freedom, or even to any system of rigid bodies. Whenever it happens that the relation of impulsive screw and instantaneous screw is interchangeable in one case, it is interchangeable in every case.

For, let $\theta_1, \ldots \theta_n$ be the co-ordinates of an instantaneous screw, then (*Theory of Screws*, p. 60) the corresponding impulsive screw has for co-ordinates,

$$\frac{u_1^2}{p_1}\theta_1, \ldots \frac{u_n^2}{p_n}\theta_n;$$

and if this latter were regarded as an instantaneous screw, then its impulsive screw would be

$$\frac{u_1^4}{p_1^2}\theta_1, \ldots \frac{u_n^4}{p_n^2}\theta_n;$$

but as this is to be only

$$\theta_1, \ldots \theta_n,$$

we must have

$$\frac{u_1^4}{p_1^2} = \frac{u_2^4}{p_2^2} = \ldots \frac{u_n^4}{p_n^2},$$

which shows that if the theorem be true for one pair it is true for all. The conditions, of course are, that any one of the following systems of equations be satisfied :—

$$\pm\frac{u_n^2}{p_1} = \pm\frac{u_2^2}{p_2} = \ldots \pm\frac{u_n^2}{p_1}.$$

§ 33. **A more Simple Construction for the Twist Velocity acquired by an Impulse.**—Reverting to the general case, we find that the chord AA' (fig. 22) is cut by the homographic axis at T, so that the square of the acquired twist velocity is proportional to the ratio of TA to TA'.

For, with the construction in § 29, draw HQ parallel to AT; then,

$$HQ : A'T :: H\Omega : A'\Omega,$$

$$\frac{AT}{A'T} = \frac{H\Omega}{A'\Omega} \propto \frac{1}{A'\Omega^2};$$

but we showed, in the article referred to, that $A'\Omega$ varies inversely as the acquired twist velocity, whence the theorem is proved.

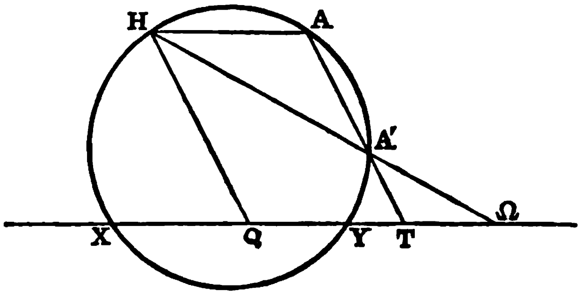

Fig. 22.

This is, in one respect, the simplest construction, for it only involves the chord AA' and the homographic axis.

The chord AA' must envelop a conic having double contact with the circle (fig. 23), for this is a general property of the chord uniting two corresponding points, A and A', of two homographic systems. Let I be the point of contact (fig. 23). Then AA' is divided harmonically in I and T; for, if XY be projected to infinity, the two conics become concentric circles, and the tangent to one meets it at the middle point of the chord in the other; the ratio is therefore harmonic, and must be so in every projection; whence,

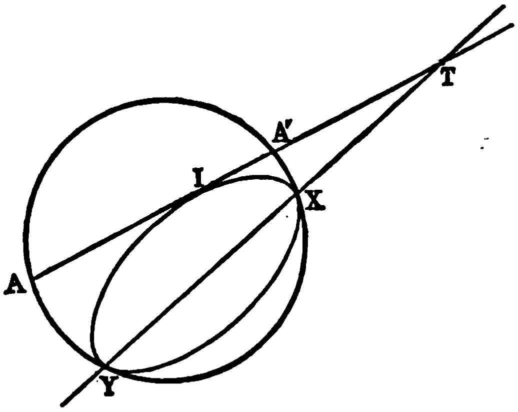

Fig. 23.

$$\frac{AI}{A'I} = \frac{AT}{A'T};$$

but the last varies as the square of the twist velocity acquired, and hence we see that—

The chord joining any impulsive screw A to the corresponding instantaneous screw A' envelops a conic, and the point of contact, I, divides the chord into segments, so that the ratio of AI to $A'I$ is proportional to the square of the twist velocity acquired about A' by the unit impulsive wrench on A.

§ 34. **Constrained Motion.**—We can now give another demonstration of the theorem in the *Theory of Screws*, p. 56, which is thus stated:—

If a body, *constrained* to twist about the screw α, be acted upon by an impulsive wrench on the screw η, then the twist velocity acquired varies as

$$\frac{\varpi_{\alpha\eta}}{u_\alpha^2}.$$

The numerator in this expression is the virtual coefficient of the two screws, and the denominator is the function of § 21, which is proportional to the kinetic energy of the body when twisting about α with the unit of twist velocity.

Let A' be α and I, η (fig. 24), and let A be the impulsive screw which would correspond to A' if the body were free to choose its natural instantaneous screw on the cylindroid defined by A and A'. Let K be reciprocal to A'.

The impulsive wrench on I is decomposed into components on K and A. The former is neutralized by the constraints; the latter has the intensity

$$\frac{KI}{KA};$$

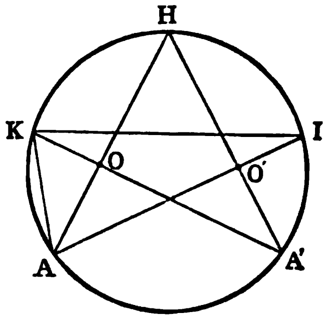

Fig. 24.

whence the twist velocity ω, acquired by A', is (§ 28) proportional to

$$\frac{KI}{KA}\cdot\frac{HO'}{HO};$$

but, by geometry,

$$KA = \frac{A'H}{OA'}\cdot OA,$$

whence, §§ 13, 21,

$$\omega \propto \frac{KI\,.\,HO'OA'}{HO\,.\,HA'OA'},$$

$$\infty\ \frac{KI\,.\,OA'}{O'A'\,.\,HA'},$$

$$\propto \frac{\varpi_{\alpha\eta}}{u_\alpha^2}.$$

This is an interesting proof of a general theorem relating to any two screws.

§ 35. **Energy acquired by an Impulse.**—The kinetic energy acquired by a given impulse, using the same notation as before, is (*Theory of Screws*, p. 56),

$$\frac{\varpi^2_{\eta\alpha}}{u_\alpha^2}.$$

Let A be the impulsive screw, and A' the screw about which the body is *constrained* to twist. Draw the chord AOH (fig. 25), then, as A' varies,

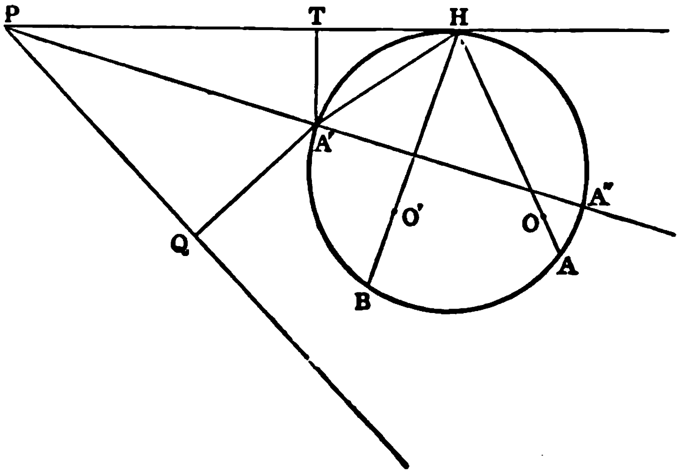

Fig. 25.

while A remains fixed, the virtual coefficient of A and A' varies as $A'H$. The square of this is proportional to $A'T$, the length of the perpendicular from A' on the tangent at H. If PQ be the axis of inertia, the value of u_α^2 is proportional to the perpendicular $A'Q$, and, accordingly, the kinetic energy acquired is proportional to

$$\frac{A'T}{A'Q}.$$

Any ray through P, the intersection of the axis of inertia with the tangent at H, cuts the circle in two points, A' and A'', either of which will accept the same kinetic energy from the given impulse.

§ 36. **Euler's Theorem.**—If the body be permitted to select the screw about which it will commence to twist, then Euler's theorem states that the body will commence to move with a greater kinetic energy than if it be restricted to some other screw. By drawing the tangent from P (not, however, shown in the figure) we obtain the point B, and at B it is obvious that the ratio of the perpendiculars on PH and PQ is a maximum, and, consequently, the kinetic energy is greatest. It follows from Euler's theorem that B will be the instantaneous screw corresponding to D as the impulsive screw. The line BH is the polar of P, and, consequently, BH must contain O', the pole of the axis of inertia. We are thus again led to the well-known construction (§ 27) for the instantaneous screw B; that is, draw AOH, and then $HO'B$.

§ 37. **To determine a Screw that will acquire a given Twist Velocity under a given Impulse.**—The impulsive screw being given, and the intensity of the impulsive wrench being one unit, the acquired twist velocity (§ 34) will vary as (Fig. 25),

$$\frac{A'H}{A'Q}.$$

If, therefore, the twist velocity be given, this ratio is given. A' must then lie on a given ellipse, with H as the focus and the axis of inertia as the directrix. This ellipse will intersect the circle in *four* points, any one of which gives a screw which fulfils the condition proposed in the problem.

§ 38. **Principal Screws of the Potential.**—Let us suppose that a body having two degrees of freedom is in a position of stable equilibrium under the influence of a conservative system of forces. If the body be displaced by a small twist, it will no longer be in a position of equilibrium, and a wrench has commenced to act upon it. This wrench can always, by suitable composition with the reactions of the constraints, be replaced by an equivalent wrench on a screw of the cylindroid (see § 23).

For every point α, corresponding to a displacement screw, we have a related point, η, corresponding to the screw about which the wrench is evoked. This relation is of the one-to-one type, and it will now be proved that the system of screws α is homographic with the corresponding system η. The proof will follow, almost word for word, that already given in § 24, for impulsive and instantaneous screws.

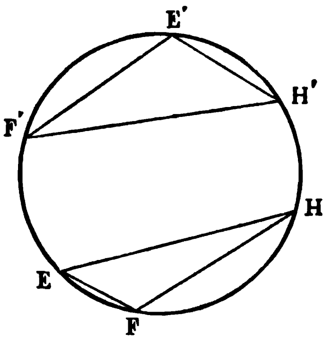

Fig. 26.

Let E be a displacement screw (fig. 26) on which a small unit of twist evokes a wrench of intensity e on E'; let f be the similar quantity for another pair of screws, F and F'.

A twist of unit amplitude about H may be decomposed into components,

$$\frac{HF}{EF}, \frac{HE}{EF},$$

about E and F, respectively.

These will evoke wrenches on E' and F' of the intensities

$$e\frac{HF}{EF}, f\frac{HE}{EF},$$

respectively. But this pair of wrenches are to compound into a wrench of intensity h on H', and consequently we have

$$h\frac{H'F'}{E'F'} = e\frac{HF}{EF},$$

$$h\frac{H'E'}{E'F'} = f\frac{HE}{EF};$$

whence,

$$\frac{HF}{HE} : \frac{H'F'}{H'E'} :: f : e.$$

If we take another pair of points, K and K', we have

$$\frac{HF}{HE} : \frac{KF}{KE} :: \frac{H'F'}{H'E'} : \frac{K'F'}{K'E'};$$

whence,

$$(HKFE) = (H'K'F'E').$$

The anharmonic ratio of any four points in one system is equal to that of their correspondents, and the two systems are therefore homographic.

The homographic axis intersects the circle in two points, which are the principal screws of the potential, *i. e.* a twist about either evokes a wrench on the same. Of course it will be understood that this homographic axis is distinct from that considered in previous articles. The two axes intersect in O the pole of the axis of pitch.

§ 39. **Work done by a Twist.**—Suppose that the body, when in equilibrium under the system of forces, receives a twist of small amplitude α'

about any screw α, a quantity of work is expended, which we shall denote by

$$Fv_\alpha^2 \alpha'^2.$$

In this, F is a constant, whose dimensions are a mass divided by the square of a time, and v_α is a linear magnitude specially appropriate to the screw α, and depending also upon the system of forces (*Theory of Screws*, p. 69). We may compare and contrast the three quantities, p_α, u_α, v_α: each is a linear magnitude specially correlated to the screw α. The first and simplest, p_α, is the pitch of the screw, and depends on the geometrical nature of the constraints; u_α involves also the mass of the body, and the distribution of the mass relatively to α; v_α, still more complicated, depends also on the system of forces.

§ 40. **Law of Distribution of v_α.**—As we follow the screw α around the circle, it becomes of interest to study the corresponding variations of the linear magnitude v_α. We have already found a very concise representation of p_α and u_α by the axis of pitch and the axis of inertia, respectively. We shall now obtain a precisely similar representation of v_α by the aid of the *axis of potential.*

It is shown (*Theory of Screws*, p. 69) that v_α^2 must be a quadratic function of the co-ordinates; we may therefore apply to this function the same reasoning as we applied to u_α^2 (§ 21). We learn that v_α^2 is at each point proportional to the perpendicular on a ray, which is the axis of potential.

Thus, if A (fig. 27) be the screw, the value of v_α^2 is proportional to AP, the perpendicular on PT; if O'' be the pole of the axis of potential, then, as in § 11, we can represent the value of v_α^2 by the product $AO''.AA'$.

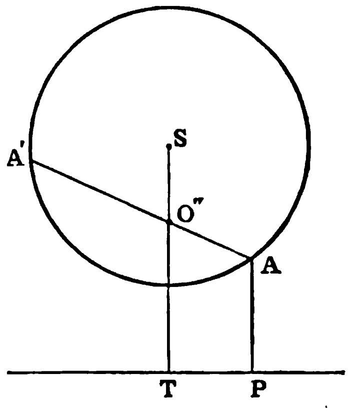

Fig. 27.

§ 41. **Conjugate Screws of Potential.**—In general the energy expended by a small twist from a position of equilibrium can be represented by a quadratic function of the co-ordinates of the screw. If, moreover, the two screws of reference form what are called *conjugate screws of potential* (*Theory of Screws*, pp. 66, 73), then the energy is simply the sum of two square terms. The necessary and sufficient condition that the two screws shall be so related is, that their chord shall pass through O''.

Another property of two conjugate screws of potential is also analogous to that of two conjugate screws of inertia. If A and A' be two conjugate screws of potential, then the wrench evoked by a twist around A is reciprocal to A', and the wrench evoked by a twist around A' is reciprocal to A (*Theory of Screws*, p. 66).

§ 42. **Determination of Wrench Evoked by a Twist.**—The theorem just enunciated provides a simple means of discovering the wrench which would be evoked by a given small twist away from a position of equilibrium.

Let A (fig. 28) be the given screw; join AO'', and find H; then the required screw A' must be reciprocal to H, and is, accordingly, found by drawing the chord HA' through O.

The axis OO'' is of course the homographic axis of § 38. We need not here repeat the demonstrations of § 28, which will apply, *mutatis mutandis*, to the present problem. We see that the ratio of the intensity of the wrench to the amplitude of the twist is proportional to

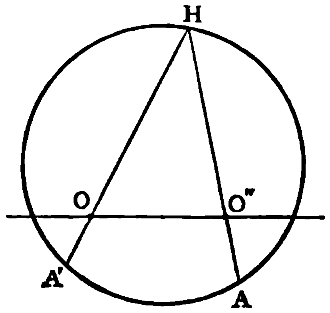

Fig. 28.

$$\frac{HO}{HO''}.$$

The other constructions of a like character can also be applied to this case.

§ 43. **Harmonic Screws.**—If after displacement the rigid body be released, and small oscillations result, the present geometrical method permits us to study the resulting movements.

It must first be shown that there are two special screws on the surface, each of which possesses the property of being an *harmonic screw.* If a body be displaced from rest by a small twist about an harmonic screw, and if it also receive any small initial twist velocity about the same screw, then the body will continue for ever to perform harmonic twist oscillations about the same screw.

The two harmonic screws are X and Y, the intersections with the circle of the axis passing through the pole of the axis of inertia O', and the pole of the axis of potential O''. (Fig. 29.)

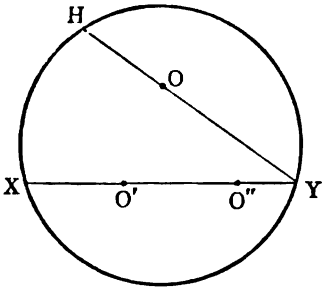

Fig. 29.

For, suppose the body receives a small initial displacement about X, this will evoke a wrench on H, found by drawing $XO''Y$ and YOH. But the effect of a wrench on H will be to produce twist velocity about a screw found by drawing HOY and $YO'X$, *i. e.* X itself. Hence the wrench evoked can only make the body still continue to twist about X, and harmonic vibration on X will be the result. Similar reasoning, of course, applies to Y.

Small Oscillations in general.—Whatever be the initial displacement, or initial twist velocity of the body, they can be always decomposed into components on X and Y. The resulting small oscillations can thus be produced by compounding simple harmonic twist oscillations about X and Y.

If it should happen that O' and O'' become coincident, then every screw would be a harmonic screw.

If O and O' coincided, then every screw would be a principal screw of inertia.

If O and O'' coincided, then every screw would be a principal screw of potential.

§ 45. **Conclusion.**—The object proposed in this Memoir has now been completed. It has been demonstrated that the representative circle affords a concise method of exhibiting every problem in the Dynamics of a Rigid System with two degrees of freedom, so long as the body remains near its initial position. The geometrical interest of the inquiry is found mainly to depend on the completely *general* nature of the constraints. If the constraints be specialized to those with which mechanical problems have made us familiar, it will frequently be found that the geometrical theory assumes some extreme and uninteresting type. For instance, a case often quoted as an illustration of two degrees of freedom, is that of a body free to rotate around an axis, and to slide along it. The representative circle has then an infinite radius, and the finite portion thereof is merely a ray perpendicular to the axis of pitch. The geometrical theory becomes attenuated, and entirely devoid of instruction.

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"CUNNINGHAM MEMOIRS."

No. V.

The Red Stars : Observations and Catalogue. By J. BIRMINGHAM. New Edition by REV. T. E. ESPIN.

[Read June 11, 1888.]

THE Red Stars must be considered as a class of heavenly bodies particularly worthy of attention; for not alone, as compared with the other stars, do they seem to differ most widely in constitution from our own sun, but they show a peculiar inclination to periodic change, while some of the most noted Variables are found amongst them.

To the Danish astronomer, Dr. H. C. F. C. Schjellerup, is justly due the merit of first directing special attention to the Red Stars, and facilitating their study by publishing, in 1866, in No. 1591 of the *Astronomische Nachrichten*, a list of them, collected obviously with considerable labour, from various authorities. Some years afterwards, it was suggested to me by my friend, the Rev. T. W. Webb, the distinguished English astronomical observer and writer, that I should undertake a revision of the Catalogue, as far as possible in this latitude, from my own observations; and, having prosecuted this task since 1872, I now proceed to lay before the Academy my notes of four years' work, and in a new and enlarged Catalogue.

The result of my observations of the stars of Schjellerup's Catalogue has been the discovery of several new variable, or probably variable stars;

and I think it right to transcribe my notes *in full*, so that other observers may be enabled in some degree to decide as to the stars, among those referred to, that may be, or may not be, advantageously watched with the view of adding to the list of Variables.

Mr. Webb, as will be seen in the notes, has contributed many observations; and I would particularly direct the attention of observers to his own Variable, S. Orionis (No. 109 in the Catalogue), one of the most remarkable discoveries of its class that has been ever made, considering the very small size of the star, even at its maximum.

My observations were made with a 4½-inch telescope, and a power of, generally, 53, and with this I could well define the colours of stars down to 10 magnitude. I have fixed the magnitudes by estimation, which I believe to be sufficiently correct; for, after a course of long and careful practice, I have been convinced, by comparing my determinations with the work of "limiting apertures," that there is little danger of my erring by so much as a half magnitude in my estimations of the larger telescopic stars. Several of the stars in Schjellerup's list are now of so pale a tint that they might seem scarcely worthy of a place there; but the possibility of change must be taken into consideration; and if a Red Star were rejected from a "Red" Catalogue because a new observer might have thought it not sufficiently deep in colour, its omission might have the effect of foregoing a chance of discovering a Variable. I must, however, remark that there are certain observers whose Red Stars seem, almost as a rule, paler to me than to the discoverers. Sir John Herschel's, for instance, seldom shows me the deep tints that he has often noted; but the differences may, perhaps, be partly accounted for by certain specialities in the performance of a large metallic reflector, compared with a small achromatic. Bond's stars, with few exceptions, appeared to me colourless.

It has been well remarked by Schmidt that no stars have been found of a perfectly red, or blood colour, such as may be seen in the solar protuberances: even stars like the "crimson" in Lepus, or Herschel's "garnet star," are no exceptions; and the reddest star that we see still shows a mixture of yellow. This perfectly agrees with my own observations; and in stars even described by myself as deep red, I must be understood to use the term only in a conventional sense, and in comparison with the other stars classified along with them.

The Red Stars seem as liable to change of tint as to change of magnitude; and, although modifications of colour may have been remarked without any striking change of size, still I have observed that as a red Variable increases it grows paler, and that it reddens deeper towards the minimum. Schmidt has made the same observation, and it well accords with the fact that all the *very* red stars are telescopic, and none of them visible to the naked eye. This is noteworthy, and seems difficult of explanation; but the cause, as I would suggest, may be found in the quality of light received from the object. As we do not see the stars by their disks, but by the amount of their light, according to apparent magnitude, it seems evident that the very red stars, shining with only a part of the components of white light, must appear less bright than the white stars, and seem, therefore, generally small. According to this view, it might be assumed that the few naked-eye reddish stars would appear larger if white; so that Aldebaran, Betelguese, &c., if of that colour, might be rivals of Sirius. The redness of a star has given rise to the singular conceit that it shows a cooling down, or, as we might say, an approach to a final snuffing out of the luminary; but one might think that the fact of periodic variation of tint in many of the Red Stars ought to go far in disproving this proposition.

It might, of course, be assumed that the changes only suggested axial rotation; but then it should be concluded that the star was more advanced in decay on one side than on the other; and such a hypothesis, if the stars resemble our own Sun in constitution, seems to me the reverse of satisfactory. It is not easy, as I can understand the matter, to conceive how the variability of a star can be assigned to a different brightness of its opposite sides, or how such a difference, if it ever existed, could long continue in a body like our Sun, where the vast physical operations that, as we know, are unceasingly going on there, must effect a constant interchange of its composing matter, and prevent any obvious and permanent difference between certain areas of its surface. Neither can the very discordant period of the most noted variables, when compared with each other, and with our own Sun's rotation, be very suggestive of an analogy which would make us refer the phenomenon of variation to movement round an axis. There are reasons, which seem confirmed by spectroscopic observations—such as Secchi's, of *o* Ceti, and Vogel's, of R Geminorum—that are opposed to the notion of periodic outbursts of incandescent gas;* and there remains the theory of the intervention and recession of nebulous matter. This seems well supported by the phenomena of the Red Stars, with their colour, like the Sun's in a fog, their broad absorption bands, and their peculiar tendency to change. The usual deepening of colour, as the star approaches the minimum, appears further to accord with this view, as it would indicate an increased thickening of the intervening veil, rather than an abatement of the star's own light. The movement of a nebulous planetary body has been suggested as the cause of variation; but this, as it appears to me, would be better explained by the hypothesis of a nebulous ring with an accumulation on one side, and a minimum thickness on the opposite; or with similar differences in several parts, which would account for the secondary periods and various irregularities that are observed in some cases; while a part of the star being left uncovered might account for the bright lines when seen at minimum. May not the yellow spectral type of our own Sun be caused by a nebulous intervention; and might not the many historical obfuscations of his light, with various durations, have been due to nebulous trains of greater or less length moving in non-re-entering courses? Of such phenomena we ourselves may remember a striking example that appeared with a cloudless sky in the west of Ireland on May 22, 1870; in Greenwich on the 23rd, and on the same day, but at a later hour, in north-eastern France—a progressive manifestation that seems to accord well with the hypothesis of moving nebulous matter.† As to the white variables, it might be said that the partially eclipsing matter should be regarded as non-gaseous, unless, indeed, it could be supposed to consist of various materials capable of absorbing light of all degrees of refrangibility, and thus acting as an impervious screen. When Secchi says that the light of Algol is partly intercepted by something opaque, I imagine that a dust ring would account for the unmodified spectral phenomena as well as for the star's variability.

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* Secchi observed that in Mira the bright lines do not become *less* bright towards the minimum; and Vogel remarked that in R Geminorum they do not *increase* in brightness, like the continuous spectrum, at maximum. Hence it may be inferred that the variability of these stars is not due to any fluctuating development of the gases that produce the lines.

† See for an account of a similar phenomenon in New England, Sept. 6, 1881, "Nature," Oct. 6, 1881, p. 540, also "Nature," Oct. 13, p. 557, letter of Harding, quoting from Hist. of Lynn. Mass., of two cases, 1716, Oct. 21, and 1780, May 19.

Instances of a complete change to a *different* colour are not wanting among the stars. It is well known that Sirius was, at one ancient period, described as red;* and in my own observations it is likely that I have found a case of similar change from red to bluish-white. I refer to the star No. 118 in the catalogue. In Schjellerup's list, where it is numbered 63, it is, of course, entered as red; but since February 2, 1873, it has always appeared to me bluish or bluish-white. I wrote early in last March to Dr. Schjellerup on the subject, requesting that he would examine the star again, and on March 25 he found it, as I had described it, no longer red. He informed me that his first observation of it was on February 22, 1863, and that its red colour must have been then very remarkable, as he *underlined* the word "rubra" in his notes, which was not his usual habit. There has been no great variation in its magnitude. Struve, in 1834, found λ Ophiuchi yellow, while Secchi, in 1867, gave it the type of Vega.† Dawes, in the interim, described it on several occasions as "white," "greenish-white," "deep yellow," and "pale yellow."‡ Struve, in 1836, noted σ Orionis as white, and the 8th mag. *comes* as ashy-grey, while Webb, in 1851, found the former yellow and the latter ruddy.

In the *Mensuræ Mitrometricæ*§ we find several Tables showing differences between the author and Sir W. Herschel in their estimation of the colours of certain stars, and from the first Table I select several examples, as follows:—

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* But, see "The Observatory," No. 120, p. 104, where Lynn shows that the probability of any change in the star's colour is very slight. In the case of λ Ophiuchi both Franks and myself have strongly suspected changes in the colours of the components (Es.).

† Catalogo, &c., *Memorie della Soc. Italiana,* 1867.

‡ Webb's *Celestial Objects for Common Telescopes.*

§ *Mens. Microm.*, &c., p. LXXXVI.

No. in Σ.	Star's Name.	H.'s Colours.	Σ.'s Colours.
90	77 Piscium.	White-red; pale red.	Albæ.
222	59 Androm.	Red-white; pale red.	Egregie albæ.
314	85 Persei.	Both pale red.	Albæ.
533	H. IV. 72.	Red-white; pale red.	Albæ.
958	H. II. 72.	Both pale red.	Albæ.
1177	17 Cancri.	Both pale red.	Egr. alba; albasubcinerea.
1224	υ Cancri.	Both pale red.	Albæ.
1540	83 Leonis.	Both inclining to red.	Albæ.
1890	39 Bootis.	Both pale red.	Alba; subpurpurea.
2021	49 Serpentis.	Both pale red.	Albæ.
2180	H. I. 66.	Both pale red.	Egregie albæ.
2281	73 Ophiuchi.	Both red.	Albæ.
2523	H. III. 57.	Both red.	Egregie albæ.

Struve, however, ascribes the discrepancies to the telescopes—he using a refractor, and Herschel a metallic reflector, which, as is well known, has a reddening tendency; but from another Table I select the following Nos., which show how, in other instances, the colours appeared not redder to H. than to Σ, but whiter.

No. in Σ.	Star's Name.	H.'s Colours.	Σ.'s Colours.
728	32 Orionis.	Fine white; white rose colour.	Subflavæ.
2055	λ Ophiuchi.	White; blue.	Flava; subcærulea.
2264	95 Herc.	White; bluish white.	Flavasubrubra; flavasubviridis.
2272	70 p Ophi.	White; white inclining to red.	Flava; purpurea.
2084	ζ Herc.	White; ash colour.	Subflava; subrubra.

While Struve refers to the discordant performances of different classes of telescopes, it may be interesting to compare his remarks with those of observers like Secchi, who also used a first class refractor; and in the following Table, where I give Secchi's notes of colours as I find them in his *Misure Michrometriche*, it will be seen that the observations of both astronomers show differences which can be explained only by the actual variability of the objects:—

No. in Σ.	Star's Name.	Σ.'s Colours.	Secchi's Colours.
60	η Cassiopeiæ.	Major flava; minor, purpurea.	1866·722; maj. alb.; min. rub. ,, ·845; maj. flav.; min. rub. ,, ·928; maj. alb; min. fla. ,, ·964; maj. fla; min. alb.
941	. . . . .	Major albacærulea; min. alba subpurpurea.	Major cærulea; min. rubra.
1110	Castor.	Major min. subvirides. [H. called both white.]	Major alba; min. aurea.
1116	. . . . .	Major min. albæ.	Major alba; min. rubra.
1273	. . . . .	Major fla. min. cærulea.	Major alba; min. flava.
1365	. . . . .	Major subfl. min. albasubcærulea.	Major flava; min. rubra.
1888	. . . . .	Major fla. min. rubro-purpurea; colores insignes.	Major alba; min. aurea.
2114	. . . . .	Major min. albæ.	Major flava; min. cærulea.
2218	. . . . .	Major alba; min. cinerea.	Major min. flavæ.
2264	95 Herculis.	1828·71; maj. flava-subviridis; min. flavasubrubra. 1828·76; maj. subvirid.; min. subflava. 1829·62; maj. viridiflava; min. egregie rubra.	1873·529; maj. rubra; min. viridis.
2272	79 p Ophiuchi.	Major fla.; min. purpurea. [H. called the larger white and the smaller reddish.]	Major alba; min. aurea.
2281	73 Ophiuchi.	Major min. albæ.	Major flava; min. subrubra.
2382	ε Lyræ.	Major albasubvir.; min. albasubcærulea.	Major viridis; min. rubra.
2545	. . . . .	Major alb. min. cærulea.	Major flava; min. cærulea.
2822	μ Cygni.	Major alb. min. albasubcærulea.	Major alba; min. flava.
3062	. . . . .	Major min. flavæ.	Major flava; min. cærulea.

It will thus be seen that the colours of certain stars seemed completely altered after a lapse of several years; and in some cases equal changes were noticed by a single observer within very short periods. It will be also remarked that there are instances where the tint of one component of a double star appeared the same both to Struve and to Secchi, though they differed widely in describing the companion. This fact seems of special interest; for the agreement in one case makes it more obvious that the great discrepancies in the other cannot well be ascribed to errors of observation, or to any cause connected with the instruments, or with personal equation.

Still there can be no doubt that a great number of the minor differences in the colours of stars, as described by different observers, are due to instrumental peculiarities, to personal equation, or some other cause not connected with actual change. Schmidt finds both Sirius and Vega slightly yellowish,* while Secchi pronounces them to be, in reality, blue stars.† He adds the remark that both of them are ordinarily considered pure white; though, for myself, I must say that Vega has always appeared to me slightly bluish. I may here notice a remarkable observation made by Secchi, who finds in spectra of the fourth type a great predominance of the green over the red, though this is the colour of the star to ordinary vision. Yet this rule is not without exceptions, as will be seen by the subjoined spectroscopic observations; and for examples, among others, where the prevailing spectral tint is indicated by the colour shown in the telescope, I may refer to D'Arrest's account of the stars, numbered 145 and 249*a* by Schjellerup, as shown in the second column of the following Catalogue.

As a hint to observers, I would remark that a space of the heavens including the Milky Way, between Aquila, Lyra, and Cygnus, seems so peculiarly favoured by the Red and Orange stars, that it might not inaptly be called "the red region," or "the red region of Cygnus;" and, although the chances of finding a star of any stated colour must, of course, be greater among the countless multitudes of the Milky Way than elsewhere, still its other portions visible in this latitude show no such special richness in coloured stars. This has been also noticed by Mr. Webb.

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* *Astronomische Nachrichten*, No. 1897.

† *Sugli Spettri Prismatici delle stelle Fisse*, &c., p. 23.

Although my original plan was to describe only my own observations of the Red Stars noted by Schjellerup, I determined subsequently to form a new list, with the positions brought up to 1880, and with several additions taken from various authorities, so as to make my work as useful as I could to the observer. In the following Catalogue I have therefore incorporated Schmidt's list of red, and golden, or reddish-yellow stars, as it appears in the *Astronomische Nachrichten*, No. 1902; and from the same journal, Nos. 2009, 2016, 2032, and 2044, I have collected several Red Stars examined spectroscopically by D'Arrest. I have also taken some from the third edition of Webb's excellent little work—*Celestial Objects for Common Telescopes*—and I have added about ninety new Red Stars found by Mr. Webb and myself, and some discovered by Mr. Burton, of the Dublin Observatory, also hitherto unpublished. I have taken some from other sources besides, including Secchi's *Prodromo di un Catalogo*, &c.; and, in a supplemental list, with positions also for 1880, I subjoin the deeply coloured stars—from red to yellow—of Struve's Catalogue of Doubles, together with several of Sir John Herschel's.

Further—considering the special interest attached to the Red Stars on account of their spectra, which often exhibit features peculiar to themselves, and, in fact, have led Secchi to his determination of a *fourth* type of stellar spectra—I thought it might be useful to add the spectroscopic observations of several stars in the Catalogue, especially as the publications from which I have taken them may not all be conveniently attainable by many observers in this country.

The observations are found in various memoirs by Secchi; in the *Prodromo di un Catalogo*, &c., by the same author; in D'Arrest's notes, published in the numbers of the *Astronomische Nachrichten* above referred to; and in Dr. Vogel's communication in No. 2000 of that journal. To an epitome of Secchi's remarks on the spectrum of No. 152 in Schjellerup's Catalogue I have appended Dr. Huggins's account as it appears in the English version, edited by him, of Schellen's "Spectrum Analysis;" and I transcribe Dr. Ball's description of some of the spectra from a private letter.

It may be right now to observe that, with regard to the positions of the stars, I can pretend to answer only for the sufficient correctness of the calculations in bringing up the places to 1880 from the places as they appeared in the several sources from which my catalogue is chiefly derived. Among those, it is true, I have found some rather obvious errors—probably misprints in most cases—which I have corrected; but, as I by no means attempted any general investigation of the positions, I consider it not unlikely that there may still have been undetected inaccuracies for which, of course, I cannot fairly be held responsible.

Mr. Birmingham, on his deathbed, wrote to the Rev. T. W. Webb, requesting him to undertake the new Edition of the Red Stars. Mr. Webb being unable to spare the time, placed it in the hands of Dr. Copeland. At the end of April, 1886, Dr. Copeland finding that it would be impossible for him to do it, wrote to me requesting me to undertake it. This I did the more willingly that the Rev. T. W. Webb had expressed a wish that I should assist in the New Edition. Arrangements were at once made for devoting the 17¼ equatorial reflector exclusively to this work. At the same time requests were sent to various gentlemen at home and abroad for observations either of objects already known or of new ones. At first it was hoped that it would be possible to reprint Mr. Birmingham's work as it stands, placing the new stars in a separate Appendix; but it soon became obvious that some line as to colour must be drawn, unless the work was to become utterly unmanageable in size. After careful consideration and consultation with several gentlemen eminently calculated to form an opinion, I decided to take out from the original Catalogue all stars that were not distinctly stated to be red, and also such stars as by a concensus of opinion are found to be only orange. These stars, together with many other ruddy stars, have been added in a separate list. The new stars that have been added to the actual Catalogue have been carefully selected, and only such stars have been admitted as are claimed by their discoverers to be really red. Out of nearly 300 red, or orange-red stars, detected by myself, less than sixty have been thought worthy of a place in the Catalogue. The Red Stars of Schmidt and Lindemann, and of the Cape and Argentine Catalogues, have been inserted in the Supplementary List. No orange stars have been added throughout the work. The number of orange and red-orange stars in the heavens is so large that the present Catalogue would probably have been quadrupled by their admission.

In the nomenclature of red tints, it is greatly to be wished that some uniform system should be adopted. The following Table gives three schemes of nomenclature:—

Espin.	Vogel.	Dunér.
Yellow.	Gelb.	June. Jaune rouge clair.
Orange.	Röthlich gelb.	Jaune-rouge.
Orange red.	Gelblich roth.	Rouge-jaune.
Red.	Roth.	Rouge jaune foncé.
Very red.	Roth.	Presque rouge absolu.

My own work was arranged as follows:—

(1). The observation of such stars of Mr. Birmingham's Catalogue as seemed to merit special attention.

(2). A search for new red stars.

(3). The spectroscopic observation of all stars not previously observed with the spectroscope.

The telescope used since 1885, Sept., is a fine equatorial Newtonian reflector of 17¼ inches aperture, with circles reading to five seconds of time, and single minutes of arc. It is fitted with a driving clock, slow motions, &c. The sweeping power has been used almost exclusively, and magnifies 70 times. It has a field of 45′; occasionally higher powers of 100; 200; have been used. The instrument was made by Mr. George Calver. In this instrument many of Mr. Birmingham's Red Stars are found to be only orange or orange-red. At first it was thought that this was due to the colour being lost in excess of light, but a careful examination of all the observations has convinced me that the real red stars such as V and U, Cygni, &c., appear equally red in all instruments, and also in moonlight and twilight. Great care has been taken in estimating the colours, and it has been customary to observe in the course of each night one or two standard stars. Below will be found a Table of these:—

No.	Birm.	Schj.	Name or Place.	Colour.						
				Bm.	W.	C.	D.	Du.	Fr.	Es.
4	4	3	0h 14m + 44° 6′,	RR	—	R	RR	RR	RR	RR
109	94	49	R Leporis, . . .	—	RR	RR	RR	RR	RR	RR
285	214	117	T Cancri, ...	—	—	RR	RR	—	—	RR
300	228	123	R Leonis, ...	R	RR	RR	RR	RR	RR	RR
495	448	—	XVIII. 28 + 36° 54′,	RR	RR	—	—	RR	RR	RR
612	553	239*a*	U Cygni, ...	RR	RR	RR	—	RR	RR	RR
630	—	—	V Cygni, ...	RR	R R	—	—	RR	—	RR

There is a tendency to over-estimate the colours of the red stars at the first view. Throughout my work the star has been observed before putting on the spectroscope, and afterwards, thus allowing several minutes to elapse, and a second independent estimate of colour to be made. The second determination is probably the most correct, and has therefore been adopted. It may be well to note, in passing, that the instrument is used in the open air. The shed which protects it runs right off on a tram, and inside is a table, carrying books, eye-pieces, and a lantern, the direct light of which is shielded from the eye. In addition to the observation of Mr. Birmingham's catalogued stars, a special search has been made for new red ones: only those stars which are very red have been inserted in the Catalogue. In the Secondary list will be found those stars which are red or orange-red. Excluding variable stars, probably the work of discovering new red stars in the Northern Heavens is complete as far as mag. 8·5.

That almost all the very red stars are variable to a considerable extent seems to me an established fact. Although the estimations of magnitude for these objects are particularly liable to large errors, yet direct comparison with neighbouring stars shows that in most cases the variation is real. The stars of the IV. type are especially subject to slight and irregular variations. The features of the variation are so distinct that I have been led to class them together as a new and special class. The variation is generally 1·0 Mag. to 1·5. The leader of this class is 19 Piscium, whose fluctuations in light were very carefully watched from 1881 to 1887. The extreme fluctuations of the star observed by me are from 4·8 to 6·2. This star was observed to be of unusual brilliancy on September 15, 1886, by Mr. Gore and myself independently. Stars which I suspect to belong to this class have a note to that effect attached to them in the Catalogue. The following new variable stars have been detected during the course of the present work:—

No.	Name.	R.A.	Decl.	Colour.	Variation.	Spectrum.
11	V Cassiopeiæ.	0^h 40^m	+ 47°. 39′	Very red.	7·5 – 14·0	III!!
89	Tauri.	IV. 22	+ 15. 51	Red.	8·2 – 13·5	III!!!
—	R. Canum.	XIII. 44	+ 40. 05	Orange red.	7·2 13·8	III!!
503	Aquilæ.	XVIII. 33	+ 8. 44	Fine red.	6·5 – 9·0	III!!!
548	Aquilæ.	XIX. 17	+ 17. 27	Very red.	8·3 – 9·5	III!!!
589	Cygni.	XIX. 58	+ 49. 42	Red.	7·5 – 13·0	III!!!
615	Cygni.	XX. 18	+ 40. 06	Red.	7·9 – 9·0	III!!!

Turning now to the Catalogue itself, it will be seen that the new edition is carried out on the same lines as those laid down by Mr. Birmingham.

Column 1 contains a current number.

Column 2, Mr. Birmingham's number.

Column 3, Schjellerup's number.

Column 4, the star's designation. For the new stars the zone and number in the D. M. are given. It should be borne in mind that the zones with a *minus* sign, from – 2° to – 22° belong to Schönfeld's continuation of the D. M.

Columns 5, 6, 7, 8, give the star's place in Right Ascension and Declination for 1890, with its respective precessions.

The following Catalogues have been consulted for the places of the stars :—

(1). The *Dunsink Observations*, containing the places of 321 red stars. The precessions have not, as a rule, been altered, as no further accuracy is required than to secure identification.

(2). The *Argentine General Catalogue.*

(3). The *Madras Observations*, 1862–64, for some of the variable stars.

The precessions for those stars whose places depend on the D. M. have been taken from a very valuable Table of Precessions contained in the Washburn Observations, vol. ii., p. 261, and in some cases have been immediately calculated from the formula there given, viz.—

$$\Delta\alpha = m + n \sin . \alpha \operatorname{tg} \delta, \quad \Delta\delta = n \cos \alpha,$$

taking into account the variations of m and n for 1890.

Column 9 contains the star's magnitude in the D. M. of Argelander and Schönfeld, and for stars still further south in the Argentine General Catalogue. A comparison of the scales of the D. M. of Argelander and Schönfeld will be found in the introduction to the Bonner Sternverzeichniss Vierte Section, p. 48.

There is a preliminary discussion of the true magnitudes of the D. M. in the Annals of the Harvard College Observatory, vol. xiv., part ii., pages 362–364, for the brighter stars, and in vol. xiii., part ii., pages 352–356, for the fainter stars.

Column 10 contains the current number for convenience of reference.

Column 11 contains the observations quoted from Schjellerup, which are distinguished by *Schj.'s notes*, and are included between inverted commas.

Then follow the observations, as given in the first edition, Mr. Birmingham's observations being marked as *B.'s obs.*, while the observations of Messrs. Webb, Copeland, &c., are preceded by their own names. The new matter of the Catalogue commences with the words, *Addit. obs.*

The sources whence this is chiefly drawn are given below. As will be seen, a very large proportion of the new matter has not been before published;

and my thanks are especially due to Miss E. Brown, Messrs. Baxendell, Dreyer, Franks, Gage, Gore, Gemmill, Knot, Pickering, Russel, Thome, and also to Mr. Sadler, for original matter and for advice during the progress of this work.

Sources whence the Catalogue is drawn:—

Argentine Gen. Cat.,	Observations of over 32,448 stars. The stars called "crimson" have been inserted in the Catalogue: those marked red or orange-red, will be found in the list of additional stars.
Baxendell,	Private letters.
Birmingham,	M. S. observations.
Brown,	Miss E., M. S. observations.
Chambers,	A working Catalogue of Red Stars, M. N., xlvii., No. 6.
Copeland,	Dunsink observations.
Cornish,	M. S. observations.
Dreyer,	Dunsink observations and private letter.
Doberck,	Observations of Red Stars in "Copernicus," Vol. i., pp. 208–210.
Dunér,	Sur les étoiles a spectres de la troisième classe. All the stars whose colour is red or yellow-red.
Dunsink Observations,	Part iv., containing the mean places of 321 red stars.
Franks,	M. S. observations of 183 red and orange stars made with 5-in. refractor, and 11¼ reflector.
Gage,	M. S. observations; telescopes of 4¼, 6½ in. (refractors).
Gemmill,	M. S. observations.
Gore,	Catalogues of variable and suspected variable stars (R. I. A.) and private letters.
Harvard College,	Observations, vol. xiv., part ii.
Holden,	Catalogues of 203 coloured stars. Washburn observation, vol. i., p. 161; vol. ii., p. 102. All the stars are given in the Catalogue that are red.

Knott, ...	Private letters.
Konkoly, . . .	Spectroskopische Beobachtung der sterne zwischen 0° und – 15° bis zu $7{\cdot}5^{\text{ter}}$ Grösse.
Lindemann, . . .	(1) Verzeichniss von 42 neuen rothen Sternen; (2 Zweites Verzeichniss neuer rother Sterne (17) in Bulletin de l'Académie Imperiale des Sciences de St. Petersbourg, vols. v., vi.
Pechüle, ...	Expedition Danoise pour l'observation du passage du Vénus, 1882.
Pickering, . . .	Stars with remarkable spectra (A. N., 2376, 2405), and private letters.
Rosse, Earl of, . .	Observations of nebulæ. Royal Dublin Society's Transactions (Science), vol. ii.
Russel, ...	Red double stars; M. S. list of 37 red and orange stars, places for 1890.
Schönfeld, . . .	Bonner Sternverzeichniss; vierte Section.
Stone, ...	Cape Catalogue.
Thome, ...	M. S. list of 114 red stars observed at Cordoba. Dr. Thome says that "the stars of the list are all pronouncedly of some shade of red, but only these marked RR are intense." I have, therefore, only inserted in the Catalogue those marked RR. The remainder will be found in the list of additional stars.
Vogel, ...	Spectroscopische Beobachtungen der Sterne bis einschliesslich $7{\cdot}5^{\text{ter}}$ Grösse in der zone von – 1° bis + 20° declination.
Webb, ...	M. S. observations of nebulæ, double and red stars, numbering in all, 3463.

Besides the above, various volumes of the *English Mechanic*, *Nature*, the *Observatory*, the *Astronomische Nachrichten*, have been consulted.

The Magnitudes.—The question of variation makes it of paramount importance that the magnitudes of each observer should be investigated. In the following Table I have collected the observations of Birmingham, Copeland, Dreyer, Webb, and my own:—

D. M.	Birm.	Copeland.	Dreyer.	Webb.	Espin I.	Espin II.	Pickering.
4·2	4·1	—	4·1	—	—	—	4·3
4·7	4·8	5·1	4·8	—	—	—	4·7
5·2	5·0	5·5	5·1	—	—	—	5·2
5·7	5·7	6·2	5·7	—	6·1	5·8	5·6
6·2	6·5	6·3	6·1	7·1	6·7	6·8	6·0
6·7	7·0	6·8	6·7	7·4	7·0	6·9	6·5
7·2	7·3	7·7	7·3	7·7	7·3	7·3	7·0
7·7	7·5	7·8	7·6	8·2	7·8	7·8	7·5
8·2	8·5	8·5	7·9	8·8	8·0	8·0	8·1
8·7	8·8	8·6	8·5	8·7	8·4	8·5	8·7
9·2	9·1	8·7	8·9	9·2	8·7	8·7	9·6
9·5	—	9·3	9·3	—	—	9·1	10·5
Total obs. used.	277	210	281	69	257	208	—

Columns 6 and 7 contain the magnitudes of my own new red and ruddy stars, and of the observed magnitudes of stars in the first edition of the Red Stars. Column 8 gives the scale of the D. M., as found in a preliminary investigation by Professor Pickering (*Annals of the Harvard College Observatory*, vol. xiii., part ii., page 356) for the fainter stars at + 1°, and for the brighter stars (*Annals of the Harvard College*, vol. xiv., part ii., page 362). The apertures of the telescopes used for the observations from which the Table is drawn are as follows:—

Birmingham, 4·5 in.; Copeland and Dreyer, 6·38 in.; Webb, 9·33 in.; Espin, 17·25 in. The first two instruments are refractors; the second two reflectors.

Two conclusions seem warranted by the foregoing Table:—

(1). In the case of the Red Stars there is a tendency to underrate the brighter and overrate the fainter.

(2). The larger the instrument the more likely is this to occur.

The following abbreviations are made use of either in the Catalogue or in the additional list of stars:—

A.C. or A.G.C.,	Argentine General Catalogue.
B. or Bm.,	Birmingham.
C. des T.,	Conn. des Temps.
C.,	Copeland.
Ch.,	Chambers.
D.,	Dreyer.
Do.,	Doberck.
Du.,	Dunér.
Es.,	Espin.
Fe.,	Fearnley.
F., or Fr.,	Franks.
H.,	Holden.
K.,	Konkoly.
L.,	Lindemann.
Pe.,	Pechüle.
Pic.,	Pickering.
San.,	Santini.
Sc.,	Schönfeld.
Sch.,	Schmidt.
Se.,	Secchi.
Sm.,	Smyth.
Spec. cont.,	Spectrum continuous.
St.,	Stone Cape Catalogue.
T.,	Thome.
V.,	Vogel.
W.,	Webb.

COLOURS.

RR,	Very red; full red; fine red.
R,	Red.
R^1,	Pale red.
R^2,	Reddish.
O; O^1,	Orange; pale orange.
OR,	Orange red.
RO,	Red orange.
YO,	Yellow orange.
YW,	Yellowish white.
WY,	Whitish yellow.

In the list of additional ruddy stars the places have only been approximately brought up to 1890. Column 1 gives a current number; column 2, the number in Birmingham, or Lindemann, or my own lists; column 3, the letter or number of the star. It should be noted that the D. M. numbers are here printed with the *signs only*. Column 4, the R. A. and Decl. 1890, column 5, the magnitude in the D. M. of Argelander or Schönfeld, or in the Argentine General Catalogue. Column 6 contains the observations of various authorities. The abbreviation for the name is immediately followed by the observation of colour. The spectroscopic observation, should there be one, comes after the colour. Although I have not been able to examine all the red double stars of Herschel, yet a considerable number have been examined, and, as a rule, show no really red colour—a fact that has been already noted by other observers. It has therefore seemed better to omit them altogether from a Red Star Catalogue till they have all been examined.* In conclusion I may state that a very large share of the work in bringing up the star places to 1890 has been done by my young pupil Nicholas Brown, and my thanks are especially due to him for his careful and accurate work. Generally the work has been done in duplicate, and I believe accuracy has been thus ensured, so far as bringing up the places to 1890 from the various Catalogues of Red Stars is concerned.

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* For the same reason the numerous Red double stars in the "Annales de L'observatoire de Nice," vol. ii., p. 16 to p. 126, and in the "Cincinnati Observations of Double Stars" have been omitted.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
1	1	1	. . . .	0^h 3^m 40^s	+ 3^s·10	+ 63° 20′·5	+ 0′·33	8·7
2	2	2	. . . .	7 37	3·07	+ 0 31·3	0·33	9·0
3	—	—	LL 169–71, . .	9 3	3·05	− 19 32·5	0·33	5·0
4	4	3	. . . .	14 5	3·15	+ 44 5·9	0·33	8·2
5	—	—	. . . .	14 31	3·07	+ 2 25·4	0·33	—
6	—	—	D. M. + 32°. 48, .	15 9	3·13	+ 32 22·1	0·33	7·0
7	5	3*a*	T Casiopeiæ, . .	17 17	3·21	+ 55 11·0	0·33	var.
8	6	3*b*	R Andromedæ, .	18 13	3·15	+ 37 58·1	0·33	var.
9	7	3*c*	S Ceti, ...	18 28	3·05	− 9 56·3	0·33	var.
10	—	—	D. M. + 34°. 56, .	21 43	3·16	+ 34 59·6	0·33	8·1.
11	—	—	V Cassiopeiæ, . .	40 11	3·32	+ 47 39·3	0·33	var.
12	I. 4.	—	D. M. + 61°. 178,	44 43	3·55	+ 61 12·4	0·33	6·2
13	—	—	D. M. + 57°. 165,	48 24	3·52	+ 57 57·9	0·33	8·5
14	11	4	. . . .	51 3	3·77	+ 67 6·1	0·33	8·8
15	13	5	. . . .	53 11	3·04	− 6 28·5	0·32	6.8
16	14	6	. . . .	59 28	3·52	+ 52 51·8	0·32	—
17	15	—	D. M. + 52°. 262, .	I. 0 37	3·53	+ 52 54·6	0·32	6·3
18	—	—	ζ Phœnicis, . . .	3 45	2·53	− 55 50·0	0·32	—
19	18	7	. . . .	10 5	3·25	+ 25 11·5	0·32	7·0
20	19	7*a*	S Casiopeiæ, . .	11 35	4·34	+ 72 2·0	0·32	var.
21	20	8	. . . .	11 28	3·50	+ 47 6·1	0·32	7·2
22	21	9	S Piscium, . . .	11 49	3·13	+ 8 21·1	0·32	var.

No.	OBSERVATIONS.	
1	*Schj.'s notes*,	"Cape obs.: a ruby star, 8·5 magnitude."—*B.'s observations:* 1873, Jan. 24, not seen; Mar. 15, slight red tinge; Sept. 21, not seen; Sept. 28, rather reddish. 1874, Oct. 15, reddish; 10 mag.—*Dublin obs.:* Copeland; 1875, Sept. 28, and 1876, Aug. 20, deep red; 9. *Additional obs.:* 1878, Oct. 6, 8·0, R; Oct. 29, 8·2 R. 1879, Oct. 25; 8·8; orange: Dec. 8, 8·5, orange (D.). 1887, Dec. 4, 6; 8·5; red (Es.).
2	,,	"Bond, I., p. 117; garnet red; 9·5. Schj., 49; 8·7."—*B.'s obs.:* 1874, Oct. 15, fine red; 8. *Addit. obs.:* 1875, Sept. 10; 9·3 (C.). 1878, Sept. 22, Oct. 24, 9·0 R. (D.). 1884, Nov. 23; 9·0; no colour seen (Fr.).
3	Pickering,	A. N., 2376. Dunér, rouge-jaune. 7 Ceti. A. G. C., 4·3. H. P., 4·6.
4	*Schj.'s notes*,	"Krüger, A. N., 1231; intensiv roth."—*B.'s obs.:* 1873, Sept. 23, fine red; 8·2–8·5. 1874, Nov. 29, fine red; 8·2.—*Dublin obs.:* Copeland; 1875, Dec. 17, red.—*Addit. obs.:* 1878, Oct. 21, 8·0; crimson. 1879, Dec. 4, 8·3, R. (D.). 1884, Nov. 29; 8·2; fine colour, almost vermillion (Fr.). 1887, Sept. 17, 8·0; intense red colour, most wonderful (Es.).
5	Pickering,	A. N., 2376; red, and perhaps *var.*?
6	Webb,	1878, Dec. 14, 7·0; orange red, with a white star of some size, and many smaller near it.—*E.'s obs.:* 1887, Dec. 6, 7·0; fine pale orange red, with 8·0 blue near.
7	*Schj. s notes*,	"Krüger, A. N., 1830, intensiv färbung."—*Dublin obs.:* Ball; 1876, July 31, brownish-red. See Gore's Var. Star Catalogue.
8	,,	"Schönf. Cat.; stark gelbroth." See Gore's Var. Star Catalogue.
9	,,	"Schönf. Cat.; röthlich." See Gore's Var. Star Catalogue.
10	Dunér,	Presque rouge absolu.
11	Espin,	142, fine red.
12	Birmingham,	1877, March 4, pale red; 7.
13	Espin,	226. 1887, Oct. 20, very red; Dec. 7, 8·5, very red.
14	*Schj.'s notes*,	"Cape obs.: deep orange red."—*Dublin obs.:* Ball; 1876, Aug. 4, reddish.—*Addit. obs.:* 1875, Sept. 10, 8·5; deep red; Nov. 11, 8·3; pale red. 1876, Jan. 1, 8·9; light red (C.). 1878, Sept. 25, 8·5; reddish. 1879, Oct. 25, 8·8; reddish (D.). 1880, Feb. 8, reddish (Do.).
15	,,	"Schj., 340; roth; 8; Lal. 1681, 82, 83; 7, 7, 7·5. Bessel, 8·7."—*B.'s obs.:* 1874, Nov. 29, pale straw colour; 7·5.—*Addit. obs.:* 1875, Nov. 14, 8·0; white. 1876, Jan. 9, 7·6; deep orange: Jan. 15, deep yellow (C.). 1878, Sept. 23, 8·0; orange: Sept. 30, 7·0; orange (D.). A. G. C., 6·7.
16	,,	"Cape obs.: full garnet colour."—*Addit. obs.:* 1876, Jan. 15, 10·3 (C.). 1878, Oct. 31, Nov. 1, 10·0; Nov. 28 < 10. (D.). 1887, Nov. 14, 9·5; flushed (Es.).
17	Birmingham,	1871, Feb. 4, pale red, with *comes.*—*Addit. obs.:* 1887, Nov. 14, 7·0; pale orange red (Es.).
18	Russel,	*Comes*, 7, copper red; h. 3419.
19	*Schj.'s notes*,	"Bessel, Z. 445, roth; 8. D'Arrest; sehr roth."—*B.'s obs.:* 1873, Sept. 17, fine red orange. 1874, Nov. 29, fine red orange; 7·5.—*Addit. obs :* 1876, Jan. 1, 7·2; red: Jan. 9, 7·3; deep orange (C.). 1878, Sept. 25, 7·0; very deep red: Nov. 28, 7·2; orange red (D.). 1884, Nov. 14, orange red (Fr.).
20	,,	"Schönf. Cat.; roth." See Gore's Var. Star Catalogue.
21	,,	"Argelander; sehr roth."—*B.'s obs.:* 1873, Sept. 21, has a faint reddish cast. 1874, Nov. 29, perhaps reddish cast; 7·5.—*Webb's obs.:* 1874, Jan. 12, not found; a pale orange; 7 mag., not far from its place.—*Dublin obs.:* Copeland; 1876, Jan. 1, white; 8.—*Addit. obs.:* 1880, Jan. 6, 7·5; orange (D.).
22	,,	"Schönf. Cat.; röthlich." See Gore's Var. Star Catalogue.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
23	—	—	D. M. + 57°. 258, .	I.^{h} 12^{m} 59^{s}	+ 3^{s}·74	+ 57° 43′·8	+ 0′·32	8·8
24	22	10	. . . .	15 34	3·12	+ 6 23·6	0·32	8·7
25	23	10*a*	. . . .	20 3	4·06	+ 65 30·3	0·31	7·0
26	24	11	R Sculptoris, . .	21 54	2·77	− 33 7·0	0·31	var.
27	25	12	R Piscium, . . .	24 58	3·09	+ 2 18·8	0·31	var.
28	26	13	. . . .	26 12	3·91	+ 60 4·8	0·31	9·0
29	—	—	. . . .	26 27	3·84	+ 57 11·2	0·31	—
30	27	13*a*	. . . .	32 50	3·08	+ 0 48·1	0·31	—
31	30	13*c*	. . . .	36 54	3·72	+ 50 3·5	0·30	7·8
32	31	14	. . . .	47 44	4·70	+ 69 39·8	0·30	8·0
33	32	14*a*	[V] Piscium, . .	48 34	3·16	+ 8 14·4	0·30	var.
34	—	—	D. M. + 58°. 342, .	50 53	4·10	+ 58 43·7	0·29	8·6
35	—	—	D. M. + 30°. 310, .	51 43	3·45	+ 30 37·1	0·29	7·0
36	—	—	D. M. + 54°. 431, .	52 16	3·93	+ 54 17·4	0·29	9·0
37	—	—	D. M. + 21°. 264, .	53 17	3·32	+ 21 19·5	0·29	8·1
38	I. 8.	—	LL 3717, . . .	54 59	2·97	− 9 3·4	0·29	5·8
39	33	15	. . . .	55 47	3·98	+ 54 42·1	0·29	7·9
40	Appen.	—	D. M. + 6°. 319, .	56 51	3·15	+ 7 8·4	0·29	9·0
41	—	—	D. M. − 0°. 314, .	59 31	3·07	− 0 31·6	0·29	8·5
42	36	16	. . . .	II. 1 8	3·08	+ 0 55·0	0·29	8·0

No.	OBSERVATIONS.	
23	Espin, . . .	35 : 1885, Dec. 2 and 5, red : Dec. 11, 8·7. 1886, Nov. 17, 9·0 ; red. Closely f. ♅. vii. 42 ; a little N. Mr. Webb, 1877, Dec. 14, observed a star 30′ S., a little f. as pale ruby. I have never found this star.
24	*Schj.'s notes*, .	"h. 101 ; red star, 7·5, 45°, s. p. D'Arrest, 1864, Sept. 25, 9 mag. Bessel, 211, 9." *Addit. obs. :* 1880, Jan. 17, 8·2 ; reddish (D). 1887, Dec. 17, 8·7 ; no colour (Es.).
25	"	"Schönf., A. N., 1905 ; gelbroth. Hist. Cél., p. 378 ; 8 mag."—*B.'s obs :* 1876, very palest red tinge ; 7·5.—*Addit. obs. :* 1876, Jan. 1, 7·9 ; full orange (C.). 1878, Oct. 31, 7·7 ; orange : Nov. 28, 7·2 ; reddish. 1879, Oct. 25, 7·5 ; reddish (D.).
26	"	"Cape obs. : orange red." A. G. C., very red. See Gore's Var. Star Catalogue.
27	"	"Hind ; fiery looking. Schönf. Cat. ; gelbroth."—*Webb's obs. :* 1874, Jan. 10, a little flushed only ; 8·7. See Gore's Var. Star Catalogue.
28	"	"D'Arrest, *sid. neb.*, p. 27 ; rubra ; 9–10 in cumulo (Messier, 103)."—*B.'s obs. :* 1872, Feb. 10, pale red in cluster ; 9 ; reddish. 1873, June 22 and 24.—*Addit. obs. :* 1875, Nov. 14, deep red (C.). 1878, Sept. 22, 9·0 ; red : Sept. 30, 8·5 ; red. 1879, Dec. 17, 8·8 ; red. 1880, Jan. 9, orange (D.). 1885, Dec. 11, 8·0 ; middle of three just equal f. star, a brighter one p. ; red not deep but certain. 1886, Feb. 14, 0·2 below star f. 1887, Dec. 4, red, 0·3 inferior to star f. (Es.).
29	Espin, . . .	230. 1887, Nov. 15, 9·8 ; very red : Dec. 14. 9·9.
30	*Schj.'s notes*, .	"Bond : reddish ; 10."—*Addit. obs. :* 1875, 9·8 ; reddish : 1876, Jan. 1, 10·1 (C.). 1878, Oct. 1, 9·6. 1879, Dec. 18, 9·7 (D.). 1887, Dec. 17, 9·5 ; flushed (Es.).
31	"	"Schweizer ; étoile rouge présentant un petit disque, 31 Jan., 1843."—*Addit. obs. :* 1875, Dec. 24, light red. 1876, Jan. 1, 8·7 ; deep red (C.). 1878, Sept. 23, Sept. 30, 7·8 ; reddish. s. f. a very blue star (D.). 1887, Nov. 14, 8·0 ; flushed : Dec. 4, 8.3 ; certainly not red, and nothing peculiar in the star's appearance (Es.).
32	"	"Argel., 2097 ; sehr roth."—*B.'s obs. :* 1872, May 16 ; 1873, Jan. 22 and 26, pale red ; 7. 1874, Nov. 29, fine red ; 7.—*Dublin obs. :* Copeland ; 1876, Jan. 1, light red ; 7·4.—*Addit. obs. :* 1875, Nov. 11, 8·0 ; full red : Nov. 14, 8·7 ; full red (C.). 1878, Oct. 1, 8·0 ; reddish : Oct. 17, 8·0 ; very red (D.). 1885, Aug. 13, good orange (Fr.). 1888, Feb. 16, 7·2 ; orange red var. ? (Es.).
33	"	"Schönf. Cat., 1866 ; schwach röthlich."—*Addit. obs. :* 1875, Dec. 24, 7·0 ; orange. 1876, Jan. 9, 7·7 ; very deep orange. 1876, Jan. 15, 7·2 ; full orange (C.). 1878, Sept. 30, 7·5 ; pale red (D.). See Gore's Susp. Var. Star Catalogue.
34	Dunér, . .	Rouge-Jaune foncé. The star is probably identical with Holden, No. 1. 1881, July 17, fine red ; 9 mag. Holden's place, 1890, i. 49·26 + 58 42·9.
35	Pickering, .	No. 6 ; Dunér ; rouge-jaune.
36	Pickering, .	No. 7, A. N., 2376 ; star red. Dunér, rouge-jaune foncé.
37	Webb, . . .	1879, Nov. 13, 8·5 ; pale ruby, one of a wide pair, the other 9 mag., blue.—*E.'s obs. :* 1886, Nov. 18, 8·3 ; very pale red, and 9·2, bluish. 1887, Dec. 6, 9·0 ; the very palest red ; 9·5, blue.
38	Secchi, . .	Prodromo, &c., 1876 ; red.
39	*Schj.'s notes*, .	"Cape obs. : almost ruby red ; 8·5."—*B.'s obs. :* 1873, Jan. 26, pale red tinge. 1874, Nov. 29, pale red ; 8.—*Dublin obs. :* Burton ; 1876, Sept. 2, orange ; 7·0.—*Addit. obs. :* 1875, Nov. 11, 8·0 ; full red ; Nov. 14, 8·8 ; deep red : Dec. 3, 8·0 ; full red. 1876, Jan. 1, 7·7 ; full yellow (C.). 1878, Oct. 17, 7·8 ; red (D.). 1887. Dec. 16, 8·0 ; orange red (Es.).
40	h. 647, . .	Large star, deep blood-red, a very intense and remarkable colour ; small star green.—*E.'s obs. :* 1887, Dec. 4, fine red ; 9·2 : Dec. 7, fine red ; 9·2.
41	Webb, . . .	1871, Dec. 16, pale red, with distant *comes*, 11 mag. ; 320° ± 45″.—*E.'s. obs. :* 1886, Nov. 18, 8·0 ; pale red.
42	*Schj.'s notes*, .	"Cape obs. : very red ; 7. Argel. vi. ; 8 und 7·5."—*B.'s obs. :* 1873, Feb. 3, Sept. 20, and 21, slightly red. 1874, Nov. 29, slightly red ; 8.—*Addit. obs. :* 1875, Nov. 11, 7·8 ; orange : Dec. 3, full orange. 1876, Jan. 1, 7·2 ; full yellow (C.). 1878, Sept. 30, 8·0 ; pale red : Nov. 18, 8·0 ; orange (D.).

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
43	II. 1.	—	D. M. + 62°. 369, .	II.^{h} 7^m 41^s	+ 4^s·44	+ 62° 43′·4	+ 0′·28	7·0
44	38	17	R Arietis, . . .	9 51	3·40	+ 24 32·7	0·28	var.
45	39	18	. . . .	11 10	3·78	+ 44 42·0	0·28	8·3
46	40	19	"Mira Ceti," . .	13 47	3·03	− 3 28·6	0·28	var.
47	41	20	. . . .	14 15	4·18	+ 56 38·5	0·28	neb.
48	42	20*a*	S Persei, . . .	14 58	4·25	+ 58 5·0	0·28	var.
49	44	21*a*	R Ceti, ...	20 25	3·06	− 0 40·5	0·27	var.
50	—	—	D. M. + 36°. 491,	21 44	3·64	+ 36 28·0	0·27	7·7
51	—	—	D. M. + 49°. 682.	24 44	4·00	+ 49 41·3	0·27	7·0
52	45	—	D. M. + 65°. 280, .	28 37	4·82	+ 65 15·9	0·27	6·1
53	46	22	. . . .	30 27	4·30	+ 56 34·0	0·26	9·3
54	—	—	D. M. + 58°. 501,	31 35	4·44	+ 59 7·2	0·26	9·5
55	47	23	. . . .	37 23	3·60	+ 31 54·2	0·26	neb.
56	48	23*a*	T Arietis, . . .	42 11	3·34	+ 17 3·0	0·25	var.
57	—	—	D. M. + 56°. 724,	42 32	4·40	+ 56 31·4	0·25	9·4
58	—	—	D. M. + 57°. 647,	42 49	4·43	+ 57 23·6	0·25	8·9
59	50	—	. . . .	43 30	4·45	+ 57 51·5	0·25	6.2
60	51	—	D. M. + 63°. 369,	47 20	4·87	+ 63 53·0	0·25	6·5
61	—	—	L 937, ...	49 57	1·27	− 63 21·6	0·25	6·4
62	54	24	. . . .	59 24	3·07	+ 0 17·6	0·24	9·3
63	—	—	D. M. + 65°. 323,	III. 0 44	5·14	+ 65 19·1	0·23	9·0
64	—	—	D. M. + 57°. 702,	2 59	4·57	+ 57 29·0	0·23	7·9

No.	OBSERVATIONS.	
43	Birmingham, .	1877, March 8, pale red; 7·5.
44	*Schj.'s notes*, .	"Winnecke, A. N., 1224; orange f. in max. Schönf.; gelbroth." See Gore's Var. Star Catalogue.
45	"	"Cape obs.: very full red; 9. Bessel, 173 + 1^m; 8·5."—*B.'s obs.:* 1873, Feb. 3, a slight red tinge; 8·5. 1874, Nov. 29, slightly reddish; 9.—*Addit. obs.:* 1875, Nov. 11, 8·2; full orange: Nov. 14, 9·0; red (C.). 1878, Sept. 30, 8·4; reddish: Nov. 18, 8·3; orange red (D.).
46	"	"Cape obs.: very full ruby; sanguine. Schönf. Cat.; sehr roth. Argel. VI., p. 327."—*B.'s obs.:* 1873, Feb. 3, beautiful deep red, almost crimson; 8–8·5: Sept. 17, fine red; 8. 1874, Nov. 29, crimson; 9. 1875, Nov. 21, 9–9·5. *Addit. obs.:* 1884, Dec. 14, 8 ± decidedly red. 1885, Jan. 21, 3½ ± orange yellow (Fr.), Es., and others, note that this star is much less red at max. than at min. See Gore's Var. Star Catalogue.
47	"	"h. 212; a fine ruby star in the centre; 10. D'Arrest (*sid. neb.*, p. 45), * 10 m., rubra. Ich nehme an es Ist, D. M. 56°. 583."—*B.'s obs.:* 1873, Dec. 26, a red between the clusters, and, within them, two other reds smaller. Webb, with 9·4-inch silver mirror, sees five red stars in, and close to, both clusters. The Rev. T. T. Smith sees eight.
48	"	"Krüger, A. N., 1978; röthlich. Schönf.; gelbroth." See Gore's Var. Star Catalogue.
49	"	"Schönf. Cat.; gelbroth." See Gore's Var. Star Catalogue.
50	Dunér, . .	Rouge-jaune. Cette étoile est la dernière de quatre. La troisiéme est rouge-jaune sp. III. ?
51	Webb, . . .	1876, Oct. 31, pale orange red, 8, and rather larger of two: Nov. 8, clear pale ruby.—*E.'s obs.:* 1887, Dec. 6, 7·0; red, with 7·5 blue near.
52	Birmingham, .	Orange; 6·5. A faint double in field s. f.—*Addit. obs.:* 1878, Oct. 21, 6·5; pale orange: Nov. 18, 6·0 (D.). 1877, Nov. 29, 6 mag.; fine orange red (Fr.). 1880, Feb. 8, 6; slightly red: March 8, 6; not very red (Do.). 1888, Feb. 16, 6·6; orange (Es.).
53	*Schj.'s notes*, .	"Cape obs.: fine ruby red; 9."—*B.'s obs.:* 1873, Jan. 26, pale red tinge; 8·5.—*Addit. obs.:* 1875, Nov. 6, 8·8; red: Nov. 11, 8·1; deep red: Nov. 14, 8·9; red: Dec. 3, 8·7; very deep orange. 1876, Jan. 1, 8·2; deep orange (C.). 1887, Dec. 14, 8·0; red (Es.).
54	Espin, . . .	1887, March 2, 8·7; very red. 1888, Feb. 16, 9·0; red.
55	*Schj.'s notes*, .	"h. 257; has a red star, 7·5 m., 43^s·5 p. According to D'Arrest, the red star does not precede, but follows the neb.; it is, therefore, Bessel, 855."—*Addit. obs.:* 1878, Oct. 24, 7·7; orange: Oct. 28, 7·6; orange; Nov. 18, 8·0; orange; Nov. 28, 7·7. 1879, Dec. 17, 8·0; pale orange (D.). Earl of Rosse: 1850, Nov. 5, 10 mag.; red; 18′ p. neb.
56	"	"Schönf. Cat.; goldgelb." See Gore's Var. Star Catalogue.
57	Pickering, .	9 (A. N., 2376), star red.—*E.'s obs.:* 1887, Feb. 3, 9·0; red, with 9·3 near.
58	Holden, . .	2, 1881, July 28, good red star; 9 mag. Dunér, rouge-jaune foncé. L'ascension droite de l'étoile (D. M. + 57°. 647) diffère de—30^s de la position de M. Holden.
59	Webb, . . .	(Private letter): red; 7·5. Ll. 5172.—*Addit. obs.:* 1878, Oct. 21, no colour; 7·0: Oct. 31, 7·7; orange: Nov. 28, 7·5; orange red (D.). 1881, July 28, not very red; 7–8 (H.).
60	Birmingham, .	Deep red; 8. *Variable?—Addit. obs.:* certainly variable. 1879, Aug. 16, and 1881, June 8; orange (Bm.). 1878, Oct. 25, 6·6; fine red: Oct. 29, 6·5; orange red: Nov. 18, 6·7; orange: Dec. 5, 6·7; reddish (D.). 1879, Sept. 23, 6·7; orange red: Oct. 14, 5·9; orange red. 1880, Feb. 8, 6; sparkling red: Feb. 14, 6·5; red: March 8, 5 ±, good red (Do.). 1885, Aug. 15, fine orange (Fr.). 1887, Dec. 14, 6·8; orange red (Es.).
61	Thome, . .	(Private letter): very red.
62	*Schj.'s notes*, .	"Bond; red; 12."—*Addit. obs.:* 1878, Oct. 21, 9·4; no colour? Oct. 24, 9·3: Oct. 25, 9·5: Nov. 28, 9·6: Dec. 1, 9·4; no colour (D.).
63	Espin, . . .	233 1887, Nov. 15, very red; 8·8.
64	Pickering, .	10 (A. N., 2376). Dunér, rouge-jaune foncé.—*E.'s obs.:* 1887, Feb. 6, 8·0; red: Aug. 14, 7·8; very red: Nov. 15, 8·0; red.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. P.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
65	57	—	D. M. + 47°. 779,	III.^{h} 4^{m} 49^{s}	+ 4^{s}·11	+ 47° 18′·7	+ 0′·23	6·9
66	—	—	D. M. + 47°. 783,	6 2	4·12	+ 47 24·7	0·23	9·0
67	59	25	L 1040, ...	9 46	1·51	− 57 43·8	0·23	6·3
68	58	24b	D. M. − 9°. 622, .	10 11	2·92	− 9 10·7	0·23	7·0
69	60	26	D. M. − 6°. 638, .	10 55	2·96	− 6 8·2	0·23	6·3
70	—	—	L 1055, ...	14 47	2·61	− 24 31·1	0·22	5·9
71	—	—	D. M. + 71°. 201,	18 56	6·12	+ 71 28·7	0·21	6·5
72	61	—	D. M. + 54°. 685,	21 49	4·53	+ 54 59·6	0·21	7·5
73	63	26a	R Persei, . . .	23 3	3·80	+ 35 17·5	0·21	var.
74	64	27	. . . .	28 36	3·44	+ 19 26·5	0·21	8·5
75	65	27a	. . . .	32 21	5·09	+ 62 17·5	0·20	6·6
76	66	28	. . . .	36 3	3·35	+ 14 26·3	0·20	8·8
77	67	29	. . . .	37 43	4·54	+ 53 33·5	0·20	8·0
78	68	30	. . . .	38 28	2·88	− 9 57·1	0·19	7·7
79	71	31	. . . .	47 45	5·06	+ 60 47·2	0·19	5·8
80	72	32	. . . .	49 54	2·76	− 15 13·7	0·18	7·0
81	—	—	D. M. + 61°. 667, .	56 19	5·18	+ 61 29·6	0·17	7·5
82	I. 13.	—	D. M. + 32°. 743, .	IV. 5 58	3·81	+ 32 14·8	0·16	6·5
83	—	—	D. M. + 14°. 672,	8 8	4·37	+ 14 16·2	0·16	7·5
84	—	—	D. M. + 27°. 656,	14 30	3·68	+ 27 5·5	0·15	7·5

No.	OBSERVATIONS.	
65	Birmingham, .	1876, April 13, pale red; 7·5.—*Addit. obs.:* 1878, Oct. 25, 7·0; reddish (D.). 1880, Feb 8, 7; hardly red (Do.). 1887, Dec. 14, 7·0; orange (Es.).
66	Espin, . . .	234. 1887, Dec. 14, 9·0; very red, fine colour: Dec. 21, 9·0; very red.
67	*Schj.'s notes*, .	"Cape obs: high orange; 7·5. Brisbane, 511; red; 6."—*Addit. obs.:* Pechüle; 1882, Dec. 14, 6 mag. A. G. C., red.
68	"	"Piazzi, note zu III. 22 (ζ Eridani); 18ˢ præc., alia rubei coloris, 4′ ad Bor.; 7·5. Ll., 6048; 6·5. Bessel, 144; 7."—*Addit. obs.:* 1885, Dec. 13, 7·5, pale orange. 1886, Nov. 30, 7·0; very pale orange red (Es.).
69	"	"Bessel, 152; roth. Secchi; gelb."—*B.'s obs.:* 1872, Feb. 10, straw colour. 1873, Sept 28, light orange.—*Addit. obs.:* 1875, Nov. 6, 7·2; full orange: Nov. 7, 7·8; deep yellow: Nov. 11, 7·3; full orange: Nov. 14, 7·5; full orange. 1876, Jan. 1, 7·4; golden yellow: Feb. 4, 8·1; very deep orange (C.). 1878, Dec. 8, 6·7; reddish (D.). 1885, Dec. 13, 7·0; orange red, with 7·0; blue; 11′ N. 20ˢ p. (Es.).
70	Dunér, . .	Rouge-jaune.
71	"	Rouge-jaune.
72	Webb, . . .	(Private letter): good red; 7·8.—*Addit. obs.:* 1879, March 11, good red, fine contrast with larger blue star (Bm.). 1878, 7·5; red (Es.). 1878, Oct. 28, 7.5; red: Oct. 29, 7·3: Dec. 1, 7·5; quite red. 1880, Jan. 19, 7·5; reddish (D.). 1885, Aug. 15, orange red (Fr.). 1887, Dec. 14, 7·8; red; fine pale blue star near (Es.).
73	*Schj.'s notes*, .	"Schönf. Cat.; röthlich." See Gore's Var. Star Catalogue.
74	"	"Markree Cat., I., p. 70; reddish; 9."—*Addit. obs.:* 1875, Nov. 14, red; a 10 mag., 20″ n. f.: Dec. 9, 8·4; deep red: Dec. 24, 9·0; red (C.). 1878, Oct. 28, 8·6 (D.). 1887, Dec. 16, 8·7; pale red, with *comes* 10·5 f. (Es.).
75	"	"Argel., VI., p. 292; sehr roth. Birmingham; April, 1871 (A. N., 1843); ausserordentlich roth; 8."—*Addit. obs.:* 1875, Nov. 11, 7·0; deep fiery red: Dec. 14, 6·9; deep red. 1876, Jan. 15, 6·8; full red (C.). 1878, Dec. 1, 7·3; fiery red, certainly not above 7·3 (D.). 1885, Aug. 15, orange red (Fr.).
76	"	"Cape obs.: very red; 9. Bessel, 637; 9."—*B.'s obs.*: 1872, Feb. 10, not seen as a red star. 1873, Feb. 3, very pale red. 1874, Dec. 13, pale red; 8.—*Addit. obs.:* 1875, Nov. 14, 8·7; full red: Dec. 9, 8·8; reddish: Dec. 24, 8·8; deep orange (C.). 1878, Oct. 29, 8·7; orange (D.). 1886, Nov. 30, 8·5; pale red. 1887, Dec. 16, the very palest red, 8·3 (Es.).
77	"	"Cape obs.: very fiery, almost scarlet; 9."—*B.'s obs.:* 1873, Feb. 3, pale red. 1874, Dec. 26, pale red; 8·5.—*Addit. obs.:* 1876, Jan. 15, 7·7; deep orange: Jan. 21, 8·3; full red (C.). 1878, Dec. 8, 8·0; orange. 1880, Jan. 19, 8·0; yellow (D.). 1884, Dec. 12, 8·7; pale red. 1888, Jan. 10, 8·3; pale red (Es.).
78	"	"Schj., 1132; roth; 8. Ll., 6921; 7·5; Bessel, 700 ; 7·5."—*Addit. obs.:* 1875, Nov. 11, 6·5; full yellow. 1876, Jan. 28, 7·6; orange (C.). 1878, Nov. 19, 8·2; orange: Nov. 28, 8·0; reddish (D.). 1884, Dec. 12, 7.5; perhaps pale red. 1886, Nov. 30, yellow (Es.).
79	"	"Conn. d. T. XV.: rouge; 5·5. Argel., Z. 161; 7: Z. 166; 6·5. Groombr., 754; 6. Radcl., 1092; 5·3. Ll., 7112, 13; 5, und 6. Piazzi, 178; 5·5. D'Arrest, 1874; schwach gelbroth."—*B.'s obs.:* 1873, Jan. 26, pale orange.—*Addit. obs.:* 1875, Nov. 11, 6·2; full orange: Dec. 14, 6·6; deep red. 1876, Jan. 15, 7·0; full orange (C.). 1878, 5·5; orange (D.). 1878, 5·0; fine orange (Es.). 1880, Feb. 8, 6; yellow (Do.). H. P., 5·1.
80	"	"Schj., 1216; gelbroth; 8. Ll., 7272; 7. Argel., 2638; 7·5."—*B.'s obs.:* 1873, Sept. 23; reddish straw colour; a larger star, same colour, s.p.—*Addit. obs.:* 1875, 8·7; red. 1876, Jan. 28, 8·2; light red (C.). 1878, Oct. 24, 29: Nov. 19, 8·0; red (D.).
81	Espin, . . .	188. 1887, March 1, 8·0; red. 1888, Feb. 16, 7·8; red.
82	Birmingham, .	1876, Feb. 26, good red; 7·5. 1885, Nov. 30, 7·0; pale orange red. 1886, Nov. 30, 7·0; orange. 1887, Dec. 5, 7·0; orange red (Es.).
83	Vogel, . . .	531. 1881, Feb. 18, gelblich roth.—*E.'s obs.:* 1886, Sept. 14, 7·8; pale red. Miss Brown: 1887, Jan. 21, reddish yellow.
84	Webb, . . .	C. O., p. 394. Note on ϕ Tauri, Fr. red star 7, or 7·5, ¼° f.—*E.'s obs.:* 1885, Dec. 1, 7·7; orange red. 1886, Nov. 2, 7·0; red. Miss Brown's obs.: 1887, Jan. 21, pale red.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
85	73	33	. . . .	IV.^{h} 15^{m} 15^{s}	+ 2^{s}·94	− 6° 30′·5	+ 0′·15	6·8
86	74	34	. . . .	15 54	3·52	+ 20 33·6	0·15	6·5
87	75	34a	. . . .	17 10	3·57	+ 22 42·5	0·15	8·0
88	76	35	. . . .	17 39	3·08	+ 0 15·1	0·15	9·0
89	—	—	. . . .	21 42	3·41	+ 15 51·4	0·14	var.
90	77	36	R Tauri, . . .	22 16	3·28	+ 9 56·0	0·14	var.
91	78	37	S Tauri, . . .	23 11	3·28	+ 9 42·2	0·14	var.
92	79	38	. . . .	28 10	2·83	− 11 1·6	0·13	6·7
93	B I. 14.	—	47 Eridani, . .	28 54	2·89	− 8 27·8	0·13	4·6
94	—	—	R Doradûs, . . .	35 29	0·69	− 62 17·6	0·12	var.
95	—	—	. . . .	37 —	—	− 62 29·0	0·12	—
96	82	40	. . . .	38 7	3·87	+ 32 42·9	0·12	8·7
97	83	41	. . . .	39 49	6·16	+ 67 58·4	0·12	7·0
98	—	—	D. M. + 34°. 911,	41 59	3·95	+ 34 48·4	0·11	8·8
99	84	42	. . . .	42 28	4·68	+ 52 2·7	0·11	8·6
100	—	—	D. M. + 15°. 691,	44 19	3·42	+ 15 35·5	0·11	9·4
101	85	43	. . . .	44 37	3·75	+ 28 20·3	0·11	8·1

No.	OBSERVATIONS.	
85	*Schj.'s notes*, .	"Schj., 1375; gelbroth; 7·7. Ll., 8154; 6. Knorre; 6·5. Secchi; orange."—*B.'s obs.:* 1873, Sept. 21, pale yellow. 1876, Feb., slightly red; 7. *Addit. obs.:* 1875, Nov. 7, 7·4: Dec. 14, 7·0. 1876, Jan. 21, 7·3 (C.). 1884, Dec. 12, reddish; 8·0. 1888, Jan. 19, 7·2; pale orange red (Es.).
86	„	"Radd. obs., XIX.: pale red; 6·7. Piazzi, 53; 7. Ll., 8146, 47; 6, und 5·5. Bessel, 286, 88; 6, und 7. Secchi, blassroth."—*B.'s obs.:* 1872, Feb., very pale red. 1873, Jan. 20, pale orange. 1874, Dec. 13, orange; 6·5.—*Dublin obs.:* Copeland; 1875, Dec. 24, red; 7·2.—*Addit. obs.:* 1878, Oct. 24, 6·5; reddish: Nov. 19, 6·3; orange (D.). 1883, March 4, 6·5; pale red (Bm.). 1884, Dec. 12, 6½; red, but not deep, in a circle of stars. 1885, Feb. 7, 7½ pale red. 1886, Nov. 30, 6·0; orange red var.? 1888, Jan. 19, 7·0; pale orange red (Es.).
87	„	"Chacornac (Bull. Mét., April 12, 1858), éclat terne et nébuleux, 7·5."—*Addit. obs.:* 1876, Feb. 4, 7·9; very deep orange: Feb. 11, 8·1; deep orange (C.). 1878, Oct. 29, 7·8; full orange: Nov. 28, 8·0; reddish (D.). 1884, Dec. 12, 8·0; pale red. 1885, Feb., 7, 8·0; pale red. 1886, Nov. 21, 7·7 (Es.).
88	„	"Bond, I., p. 135; red; 10. Knorre (Acad. Sternk.); 9."—*Addit. obs.:* 1878, Oct. 31, 8·8; orange: Dec. 1, 9·0; orange. 1879, Jan 16, 9·2 (D.).
89	Vogel, . . .	594. 1881, Feb. 24, röthlich gelb, 9·2, fehlt bei Argelander. Espin; red, and variable, 8·2–13·5. Gage; red. Baxendell; red.
90	*Schj.'s notes*, .	"Hind; red. Goldschm., A. N., 1011; roth. Winnecke, A. N., 1224; trüb roth. Secchi; orange-gelb." See Gore's Var. Star Catalogue.
91	„	"Hind; reddish. Winnecke, keine färbung." See Gore's Var Star Catalogue.
92	„	"Schj., 1462; gelbroth; 6·7. Ll., 8623, 25; 6·5 und 6. Bessel; 7. Secchi; gelbroth."—*B.'s obs.:* 1873, Sept. 21, pale orange. 1874, Dec. 26, pale orange; 6·5.—*Addit. obs.:* 1876, Jan. 21, 7·7; deep yellow: Feb. 4, 6·8; deep orange: Feb. 11, 7·0; orange (C.). 1878, Dec. 5, 6·5; orange (D.).
93	Secchi, . .	*Prodromo*, &c.: 1876, No. 55, red; 6·7. D'Arrest, stern 6. gr. auffalend röthlich (A. N., 2032). Dunér, rouge-jaune. A. G. C., 5·4; red.—*E.'s obs.:* 1887, Dec. 4, pale orange red; 5·0.
94	Thome, . .	(Private letter); very red.
95	Russel, . .	*Comes*, 7; red; h. 3679.
96	*Schj.'s notes*, .	"Cape obs.: ruby red; 8·5. Bessel, 785; 9."—*B.'s obs.:* palest red; 8·5 in several obs., 1873, '74, and '75.—*Webb's obs.:* 1874, Jan. 19, Feb. 14, pale ruby; 9.—*Addit. obs.:* 1875, 9·2; deep red. 1876, Jan. 1, 8·3; red (C.). 1878, Dec. 5, 8·4; red. 1880, Jan. 21, 8·7; deep orange (D.). 1885, Feb. 7, 8½; pale red; a 7 mag. p.: Dec. 14, 8·5; very orange red. 1886, Nov. 30, 8·5; red (Es.).
97	„	"Arg., 5129; sehr roth; 6·5. Ll., 8823; 8. Grb., 870; 6. Radcl., 1302; 6·4. Secchi; faint red."—*B.'s obs.:* 1873, Jan. 22, orange.—*Addit. obs.:* 1876, Jan. 21, 7·5; red: Feb. 4, 7·7; full red: Feb. 11, 7·1; very deep orange (C.). 1885, Aug. 16, fiery orange red (Fr.). 1887, March 1, 7·4; very red (Es.).
98	Espin, . . .	147. 1886, Nov. 21, 8·0; red: Nov. 24, 8·3; red. 1887, March 15, 8·7. Oct. 28, 8·3; red.
99	*Schj.'s notes*, .	"Cape obs.: very fiery, almost ruby."—*B.'s obs.:* 1872, Jan. 20 and 22, March 12.; 1873, Sept. 12, 28, not seen: Dec. 19, faintest red tinge; 9. 1874, Feb. 21, faint red; 9.—*Addit. obs.:* 1876, Jan. 1, 8·6; full red, 0·1 > ✱ 4′ s. p.; Feb. 19, 8·6; deep orange (C.). 1878, Dec. 1, 8·8; orange. 1879, Jan. 16, 8·7; red (D.). 1888, Jan. 10, 8·7; pale red. 1888, Oct. 3, 8·5; pale orange red (Es.).
100	Espin, . . .	238. 1887, Dec. 21, 8·0; fine red, var.? 1888, Jan. 19, 8·6; red: Feb. 7, 9·0; red.
101	*Schj.'s notes*, .	"Cape obs.: extraordinary ruby colour; two obs.; 8. Bessel, 946; 9. Secchi; 8·7; blassroth. Birmingham (M. N., XXXIV.), hat sehr eingehend diesen stern auf variabilität geprüft."—*B.'s obs.:* 1872, Feb. 10, pale red; 8. 1873, Jan. 22, orange. 1874, Feb. 9, fine orange; 7–7·5: Feb. 15, full red; 7·5: Feb. 17, full red, but with an orange cast; 7·5: Feb. 18, scarcely more than 8: Feb. 21, colour as before; 8: Feb. 27, full red; 7·8: March 6, fine red; 8: March 12; 8: March 24, full red, near moon; 8: April 11,

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
101	85	43	. . . .	IV.^{h} 44^m 37^s	+ 3^s·75	+ 28° 20′·3	+ 0′·11	8·1
102	—	—	D. M. + 38°. 955, .	45 6	4·07	+ 38 18·9	0·11	8·8
103	86	43a	V Tauri, . . .	45 40	3·47	+ 17 21·1	0·11	var.
104	—	—	D. M. + 22°. 770,	47 12	3·60	+ 22 35·5	0·10	9·2
105	88	45	5 Orionis, . . .	47 38	3·12	+ 2 19·5	0·10	5·0
106	90	47	. . . .	49 58	3·08	+ 0 15·5	0·10	·0
107	91	—	D. M. + 39°. 1134,	52 48	4·13	+ 39 29·4	0·10	6·8
108	92	48	R Orionis, . . .	53 2	3·25	+ 7 57·7	0·10	var.
109	94	49	R Leporis, . . .	54 36	2·73	– 14 58·3	0·09	var.
110	—	—	D. M. + 38°. 1010,	55 48	4·11	+ 38 54·6	0·09	9·5
111	—	—	D. M. + 6°. 810, .	55 53	3·22	+ 6 29·4	0·09	9·2
112	I. No. 15.	—	. . . .	57 25	2·47	– 25 3·6	0·09	—
113	—	—	D. M. + 23°. 830,	57 55	3·63	+ 23 29·9	0·09	8·5
114	96	51	. . . .	59 43	3·09	+ 1 1·5	0·09	6·0
115	—	—	D. M. – 22°. 995, .	V. 0 6	2·55	– 22 2·2	0·09	8·7
116	98	52	. . . .	0 57	3·08	+ 0 24·0	0·09	9·2
117	99	—	D. M. – 5°. 1174, .	4 24	2·94	– 5 39·3	0·08	8·7
118	100	53	. . . .	4 27	3·05	– 0 42·2	0·08	6·7

No.	OBSERVATIONS.	
101	*continued*—	8·8–9 : Dec. 26, full red ; 7·5. 1875, Nov. 26, pale red ; 7·8. 1876, Jan. 13, full red ; 8 : Jan. 21, full red ; 9 : Jan. 31, full red ; 8.—*Webb's obs.:* 1874, Jan. 12, fine ruby ; 10 : March 7, pale ruby ; 9.—*Addit. obs.:* 1875, Nov. 7, 8·8 ; deep red. 1876, Jan. 21, 8·6 ; deep orange (C.). 1878, Nov. 28, 8·5 ; quite red (D.). 1879, Sept. 23, 6·5 ; very red : Oct. 14, 6·9 ; reddish (Do.). 1885, Jan. 10, fine red (Fr.). 1885, Feb. 7, 8·0 ; fine pale red : Dec. 15, 7·4 equal + 28°. 704 ; 38^{s}·6 p. 11′·4 s. 1887, Feb. 8, 7·3 ; very red : Dec. 11, 8·2, very red. *Variable.* (Es.).
102	Espin, . . .	148. 1886, Nov. 3, 8·3 ; very red : Nov. 21, 8·5 : Nov. 24, 8·3 ; very red. 1887, Oct. 28, 8·3 ; very red.
103	*Schj.'s notes*, .	" Schönf. Cat. ; röthlich." See Gore's Var. Star Catalogue.
104	Espin, . . .	149. 1886, Nov. 21, 9·0 ; very red. 1887, Oct. 18, 9·0 ; very red : Dec. 16, 9·8 ; *comes* 10″, 11·3 mag.
105	*Schj.'s notes*, .	" Conn. des Temps ; rouge ; 5·5. Piazzi, 226, 6. Bessel ; 6·5. Secchi ; blassroth."—*B.'s obs.:* 1872, Feb. 10, and 1873, Jan. 22, pale orange ; 5·5.—*Webb's obs.:* 1874, March 11 ; pale orange 7.—*Addit. obs.:* 1876, Jan. 1, 6·0 ; yellow : Feb. 19, 6·5 ; deep yellow (C.) 1878, Sept. 5, Dec. 23, 5·7 ; fine red (Es.). 1880, Feb. 5, 5·0 ; orange (D.). 1880, Jan. 30, 5·5 ; red (Do.). 1883, Feb. 3, splendid very red orange (Bm.). 1886, Feb. 26, orange (Fr.). Gould variable. See Gore's Susp. Var. Star Catalogue.
106	"	" Bond, ruby ; 10. Bessel, 9."—*Addit. obs.:* 1876, Jan. 28, 9·1 ; red : Feb. 19, 8·7 ; deep red (C.). 1878, Nov. 19, 9·0 ; orange (D.).
107	Birmingham, .	1876, May 3, fine red ; 6·4.—*Addit. obs.:* 1884, Dec. 16, 6·9 ; fine red. 1885, Feb. 7, fine pale red, 7·0 ; ✱ 6·4, 15′·6 s. yellow (D. M. + 39°. 1133) ; Oct. 24, 6·0 ; orange red : Nov. 30, 6·5 ; orange red. 1887, Dec. 16. 7·0 ; pale orange red ; a 6·4 blue s. (Es.).
108	*Schj.'s notes*, .	" Hind ; reddish. Schönf. ; stark röthlich. Secchi, goldgelb." See Gore's Var. Star Catalogue.
109	"	" Hind ; crimson. Schönf. ; intensiv blutroth." See Gore's Var. Star Catalogue.
110	Espin, . . .	150. 1886, Nov. 3, 8·5 ; very red. 1887, Oct. 28, 8·4.
111	Dunér, . .	rouge-jaune.
112	Burton, . .	(Private letter) ; red ; 10·0. Espin, several trials, Dec. 1887 ; not seen.
113	Webb, . . .	1878, Feb. 7, very pale ruby ; 8·5 ; in *s. f.* part of a cluster. *E.'s obs.:* 1886, Nov. 18, 8·0 ; yellowish red. 1888, Feb. 7, orange red ; 8·2.
114	*Schj.'s notes*, .	" Hist. Cél., pp. 49 und 316 ; rouge ; 7 und 7·5. Bessel, 1296 ; roth ; 7."—*B.'s. obs.:* 1871, Feb. 20, fine red ; 6. 1873, Jan. 22, yellow ; flushed pale red. 1876, Feb, 19, splendid red ; 7.—*Webb's obs.:* 1874, March 11, pale ruby ; 8.—*Addit. obs.:* 1876, Jan. 28, 6·0 ; full red ; Feb. 19, 6·3 ; full red (C.). 1878, Nov. 28, 6·5 ; very red. 1879, Jan. 25, 6·3 ; deep orange (D.). 1880, Jan. 30, 5·3 ; fiery red (Do.). 1883, Feb. 12, 8·0 ; fine ruby (W.). 1885, Jan. 31, fine orange (Fr.). 1886, Nov. 17, 5·5 ; very orange red, *var.* ? (Es.).
115	Holden, . .	89. 1882, Feb. 7–8, 9·5 ; fine red.—*E.'s obs.:* 1887, Dec. 7, 8·5 ; very red. 1888, Jan. 10, 9·0 mag. ; very red. 1888, Dec. 30, 8·0 ; red.
116	*Schj.'s notes*, .	" Bond, I., p. 179 ; ruby ; 9."—*Webb's obs.:* 1874, March 18, not found.—*Addit. obs.:* 1876, Jan. 21, 9·1 ; deep yellow (C.). 1878, Nov. 19, 9·2. 1879, Jan. 22, 9·0 ; red (D.).
117	Webb, . . .	(Private letter) ; fine red. Weisse's Bessel ; V., 29.—*B.'s obs.:* 1876, Sept. 3, fiery red in full moon and dawn ; 7·5.—*Addit. obs.:* 1871, Jan. 16, decided but not deep red ; 9·0 ; star *sp.* 9·5 : Feb. 18, 9·2. 1872, Dec. 26, 9·2. 1875, Nov. 20, 9·3. 1877, Dec. 25, 9·6. 1878, Jan. 23, 9·4. 1883, Feb. 14, 9·3 (W.). 1878, Dec. 30, not above 9·2 ; perhaps reddish. 1879, Jan. 3, 8·0 ; red. 1880, Feb. 8, 8·0 ; reddish : Feb. 14, 8·2 ; reddish (D.). 1884, Dec. 14, good colour, not more than 8·5 (Fr.). 1885, Dec. 16, 8·0 ; very red. 1886, Nov. 3, 8·0 ; red (Es.).—Dublin obs.: 1^{m} too little.
118	*Schj.'s notes*, .	" Knorre ; roth ; 7. Schm. ; gelb ; 6·5. Ll., 9744 ; 7. Bessel, 27 ; 7."—*B.'s obs.:* always pale straw-colour, about 7 mag., in several obs. from 1873 to 1876.—*Webb's obs.:* 1874, March 18, very pale orange ; 7·5.—*Addit. obs.:* 1880, Jan. 30, 7 ; faint red (Do.). Vogel, 1880, Jan. 19, gelblich weiss. U. A., 6·5, C. ; H. P., 6·4.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
119	—	—	D. M. − 2°. 1161,	v.^{h} 5^{m} 26^{s}	+ 3·02	− 2° 22′·8	+ 0′·08	7·0
120	I. No. 16.	—	D. M. − 12°. 1092,	6 14	2·79	− 11 59·3	0·08	6·5
121	101	53*a*	R Aurigæ, . . .	8 24	4·82	+ 53 27·8	0·07	var.
122	102	—	D. M. − 0°. 890, .	9 0	3·06	− 0 41·2	0·07	7·0
123	—	—	D. M. + 42°. 1240,	10 44	4·28	+ 42 40·6	0·07	9·0
124	I. No. 18.	—	D. M. + 40°. 1245,	11 13	4·21	+ 40 58·7	0·07	7·3
125	—	—	D. M. + 35°. 1046,	11 48	4·01	+ 35 40·4	0·07	8·9
126	—	—	D. M. − 8°. 1079,	12 44	2·88	− 8 20·4	0·07	8·0
127	103	54	. . . .	12 30	4·14	+ 39 13·6	0·07	7·6
128	104	55	. . . .	13 34	3·96	+ 34 9·3	0·07	7·9
129	105	56	. . . .	13 46	3·08	+ 0 15·1	0·07	—
130	—	—	D. M. + 32°. 957, .	14 39	3·90	+ 32 23·7	0·06	9·3
131	107	57	. . . .	18 1	2·85	− 9 25·8	0·06	8·6
132	—	—	D. M. − 10°. 1178,	19 50	2·83	− 10 25·7	0·06	6·3
133	108	57	S Aurigæ, . . .	19 51	3·96	+ 34 3·2	0·06	var.
134	—	—	D. M. + 22°. 907,	20 19	3·63	+ 22 51·8	0·06	9·0
135	—	—	D. M. + 22°. 909,	20 38	3·63	+ 23 0·4	0·06	9·3
136	—	—	D. M. − 9°. 1150,	20 27	2·85	− 9 38·6	0·06	8·0
137	—	—	D. M. + 29. 897, .	20 8	3·82	+ 29 49·7	0·06	8·0
138	109	57*h*	S Orionis, . . .	23 35	2·96	− 4 46·9	0·05	var.
139	—	—	D. M. − 3°. 1116, .	23 55	2·99	− 3 32·6	0·05	6·3
140	110	58	31 Orionis, . . .	24 9	3·04	− 1 10·8	0·05	5·5
141	111	59	119 Tauri, . . .	25 46	3·51	+ 18 30·7	0·05	4·4

No.	OBSERVATIONS.	
119	Konkoly, . .	1884, Jan. 18, 7; gelblich roth. Nach Ll. (9759); 6.
120	Burton, . .	(Private letter); very red. See Gore's Catalogue. Also E. M., Jan. 15, 1886, for variation.
121	*Schj.'s notes*, .	"Schönf. Cat.; roth."—*E.'s several obs.:* 1886–7; very red. See Gore's Var. Star Catalogue.
122	Webb, . . .	(Private letter); pale red; 8.—*Addit. obs.:* 1880, Jan. 30, 7; faint red (Do.).
123	Dunér, . .	Rouge-jaune foncé.
124	Webb, . . .	(Private letter); 1877, Feb. 3, pale ruby.—*B.'s obs.:* 1877, Feb. 18, good red; 7·7—*Addit. obs.:* 1888, Jan. 19, 7·3; pale orange red (Es.).
125	Espin, . . .	50. 1885, Nov. 20, 8·5; very red, in a curve of stars. Always 8·5; several obs. from 1885 to 1887.
126	Webb, . . .	1878, Jan. 25, pale ruby, 8·5.—*E.'s obs.:* 1885, Dec. 7, 8·5; very orange red. 1888, Feb. 7, 8·2; pale red.
127	*Schj.'s notes*, .	"h. 350; ruddy, almost orange; 7. D'Arrest (*sid. neb.*, p. 76); stella rubra; 9 mag., non utique lucidior."—*B.'s obs.:* 1873, Feb. 2, palest straw colour: Sept. 21, very pale red, 7–8.—*Webb's obs.:* 1874, March 26, not found as a red star.—*Addit. obs.:* 1876, Jan. 21, 8·1; deep orange: Feb. 19, 7·5 (C.). 1879, Jan. 22, 8·0; red (D.). 1884, Dec. 16, 8·0; pale red. 1888, Jan. 19, 8·7; very pale red; *var.*? (Es.).
128	„	"Cape obs.: remarkably red; 8. Ll., 9919; 8·5."—*B.'s obs.:* 1873, Jan. 22, no colour observed; Feb. 3, slight red tinge; 8·5. 1875, Jan. 25, reddish; 9. 1876, Jan. 21, no colour observed—*Webb's obs.:* 1872, March 26, April 5, very pale red; 9.—*Addit. obs.:* 1876, Feb. 5, 7·9; full orange (C.). 1878, 8·0; orange. 1879, Jan. 25, 7·5 (D.). 1888, Jan. 9, 8·5; pale orange red (Es.).
129	„	"Bond, I., p. 181; reddish."—*Addit. obs.:* 1876, Jan. 1, 9·1; orange: Feb. 11, 9·3; pale orange (C.). 1880, Feb. 4, 9·0; s. p. of two (D.).
130	Espin, . . .	154. 1886, Nov. 30, 9·0; very red. 1887, Oct. 28, not more than 10: Nov. 4, 9·5: Nov. 14, 9·3: Dec. 4, 9·2: Dec. 16, 9·3; very red.
131	*Schj.'s notes*, .	"Schmidt; sehr roth; 8·5."—*B.'s obs.:* 1873, Jan. 22, not red: Dec. 19, very faintest red tinge. 1876, March 13, reddish; 9–10.—*Addit. obs:* 1876, Jan. 1, 8·1; deep orange: Feb. 4, 8·2; pale red: Feb.19, 8·9; red (C.). 1878, Dec. 8, 8·0 (D.).
132	Konkoly, . .	7; gelblich roth. Ll., 10184, 6. mag.
133	*Schj.'s notes*, .	"D'Arrest (17 Nov. '68); sehr roth; 9·5."—*B.'s obs.:* 1876, March 13, not seen. See Gore's Var. Star Catalogue.
134	Webb, . . .	1871, April 4, 8·5; pale ruby.—*E.'s obs.:* 1887, Dec. 6, 9·0; pale red; Dec. 7, 8·8; red.
135	Webb, . . .	1871, April 4, 9·0; ruby.—*E.'s obs.:* 1887, Dec. 6, not red: Dec. 7, 9·3; reddish.
136	Konkoly, . .	1884, Feb. 20, 6; gelblich roth. Ll., 10200, 7·5.
137	Espin, . . .	52. 1885, Nov. 14, 8·0; very red; so Nov. 16 and 20. 1876, Sept. 14, 7·5; very orange red: Nov. 3, 7·7; red. 1888, Feb. 7, 7·5; red; fine star.
138	*Schj.'s notes*, .	"Webb (M. N., XXXI., p. 84); red; 10. Schj., 1796; 8·7." See Gore's Var. Star Catalogue, also E. M., 1887, Dec. 2, p. 322.
139	Konkoly, . .	1884, Jan. 18, 6; gelblich roth. Ll., 10330. A. G. C., 6·5. Schönf. röthlich.
140	*Schj.'s notes*, .	"Hist. Cél.; rouge; 5. Schm.; gelbroth. Secchi; goldgelb."—*B.'s obs:* 1873, Jan. 22, pale straw colour; a minute *comes;* 12; 90° (estim.). 1874, April 11, light orange. 1876, Jan. 21, yellow orange; 5: beautiful contrast with blue *comes.*—*Addit. obs.:* 1876, Feb. 4, 5·0; golden yellow. 1876, Feb. 11, 5·8; deep yellowish orange (C.). 1879, Jan. 11, 5·0; deep orange (D.) 1880, Jan. 30, 6; faint red (Do.). 1885, Jan. 27, fine orange (Fr.). U. A., RR.; variable. See Gore's Var. Star Catalogue.
141	„	"Conn. des Temps; rouge; 5·5. Siehe Piazzi, 127, note."—*B.'s obs.:* 1873, Feb. 2, orange. 1875, Jan. 25, deep orange; 5·5.—*Dublin obs.:* Copeland; *near* Schj., 59,

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
141	111	39	119 Tauri, . . .	v.^{h} 25^m 46^s	+ 3^s·51	+ 18° 30′·7	+ 0′·05	4·4
142	—	—	D. M. + 7°. 929, .	27 17	3·24	+ 7 3·8	0·05	8·2
143	I. No. 21.	—	D. M. + 25°. 863, .	28 2	3·71	+ 25 49·0	0·05	8·4
144	112	—	D. M. + 3°. 966 ? .	28 42	3·16	+ 4 0·3	0·05	9·3
145	—	—	D. M. + 20. 1007, .	28 56	3·57	+ 20 43·8	0·04	9·1
146	—	—	D. M. + 68°. 398, .	29 7	6·45	+ 68 44·3	0·04	9·3
147	114	60	. . . .	30 58	3·33	+ 10 58·0	0·04	6·5
148	115	61	. . . .	31 47	3·69	+ 24 56·2	0·04	9·5
149	I. No. 22.	—	124 Tauri, . . .	32 34	3·64	+ 23 15·2	0·04	7·8
150	I. No. 23.	—	D. M. + 31°. 1058,	35 3	3·90	+ 31 49·1	0·04	8·9
151	117	62	. . . .	35 29	2·98	− 3 54·1	0·04	8·0
152	120	64	. . . .	38 29	3·67	+ 24 22·3	0·03	8·5
153	121	64*a*	. . . .	39 6	3·57	+ 20 38·9	0·03	7·7
154	124	65	. . . .	40 10	1·67	− 46 30·2	0·03	7½
155	122	64*b*	. . . .	40 10	3·59	+ 21 9·4	0·03	8·8
156	—	—	D. M. + 44°. 1288,	40 32	4·39	+ 44 48·0	0·03	9·2
157	125	—	D. M. − 5°. 1389, .	40 55	2·93	− 5 54·6	0·03	9·0
158	123	64*c*	. . . .	41 3	3·86	+ 30 35·4	0·03	8·5
159	I. No. 25.	—	D. M. + 32°. 1113,	45 7	3·92	+ 32 31·4	0·02	9·0
160	I. No. 26.	—	D. M. + 32°. 1118,	46 6	3·91	+ 32 9·2	0·02	8·7
161	128	—	D. M. + 7°. 1045,	47 43	3·23	+ 7 8·8	0·02	9·4

No.		OBSERVATIONS.
141	*continued*—	a red; 8·9.—*Addit. obs.:* 1876, Jan. 21, 5·0; deep orange: Feb. 29, full red (C.). 1879, 4·5; deep red (D.). 1884–86, Gemmill, fine orange. 1885, Jan. 10, very fine orange (Fr.).
142	Espin, . . .	156. 1885, Dec. 16, 7·8; very red. 1886, Jan. 1, 5: March 6, 8·0; very red: Sept. 14, Nov. 3, 7·7; very red.
143	Webb, . . .	(Private letter): 1877, pale red; 9.—*B.'s obs.:* 1877, Feb. 26, pale red, 8·5.—*Addit. obs.:* 1888, Jan. 9, 8·5; pale red (Es.).
144	Webb, . . .	(Private letter): red. Ll. 10646; 8·5.—*Addit. obs.:* 1888, Jan. 10, 19; 9·0; no colour (Es.).
145	Webb, . . .	1887, Feb. 3; 10 mag.; ruby: Feb. 8, colour almost questionable.—*E.'s obs.:* 1887, Dec. 7, 8·5; pale red
146	Espin, . . .	191. 1877, Feb. 28, red; a *comes* 11·0. March 1, 8·2; red: March 3, 8·0; *comes* 11·5, 10″ ± 280° ± with two more distant ones. Nov. 14, 8·0; *variable?*
147	*Schj'.s notes*, .	"Hist. Cél., p. 311, rouge; 7·5. Schm. (Acad. Sternk.); gelbroth. Bessel, 718; 7."—*B.'s obs.:* 1873, Feb. 2, pale straw colour; 7. 1875, Jan. 25, fine orange; 7·5.—*Addit. obs.:* 1876, Jan. 21, 6·0; deep orange (C.). 1879, Jan. 3, 15, 6·5; orange. 1885, Feb. 25, 7·0; yellow (Es.).
148	”	"Markree Cat. II.., p. 13; red; 9·5."—*Dublin obs.:* Copeland; deep red or brown.—*Addit. obs.:* 1876, Jan. 1, 9·2; deep red, n. f. of two (C.). 1880, Feb. 5, 9·5 (D.). 1887, Dec. 17, 9·5; very red (Es.).
149	Smyth,	CCXXI.; garnet; 8·5. Webb; red.—*Addit. obs.:* 1885, Jan. 10, fine orange red (Fr.). 1888, Jan. 9, 7·9; orange red: a double star near (Es.).
150	Burton, . .	(Private letter); strong red; 8·7.—*Addit. obs.:* 1888, Jan. 9, 10, yellowish (Es.).
151	*Schj.'s notes*, .	"Schj., 1878; roth; 8. Ll., 10743; 8."—*B.'s obs.:* palest red tinge, in several obs.; 8.—*Webb's obs.:* perhaps a little flushed; 8.—*Addit. obs.:* 1876, Jan. 21, 7·2; full orange: Feb. 19, 8·0; deep orange (C.). 1878, Dec. 5, 8·0; reddish. 1879, Feb. 5, 7·7; orange (D.). 1888, Jan. 10, 7·8; the palest red (Es.).
152	”	"Markree Cat., I., p. 76; very red; 8."—*B.'s obs.:* 1873, Feb. 2, pale red; 8: Dec. 26, fine red; 8·3. 1875, Jan. 25, very red; 9·5. *Decidedly var.*—*Dublin obs.:* Ball; 1876, Oct. 9, very red.—*Addit. obs.:* 1876, Feb. 4, 8·4; full red: March 4, 7·7; full red (C.). 1879, Jan. 16, 8·7; red (D.). 1885, Jan. 10, 8·0; fine colour (Fr.). 1885, Nov. 28, 8·0; very orange red. 1887, Dec. 11, 8·5; red: Dec. 17, 8·0; red (Es.).
153	”	"Markree Cat., III., p. 41; very red; 8. Arg., VI., p. 109; sehr roth."—*B.'s obs.:* 1876, Jan. 21, very fine ruby; 7·7: Feb. 19, splendid crimson; 7; probably *var.*—*Addit. obs.:* 1875, Nov. 7, 8·0; full red. 1876, Jan. 21, 7·6; full red (C.). 1878, Dec. 30, 7·8; red. 1879, Jan. 3, 7·5; red (D.). 1883, Feb. 3, very deep red orange; 7·0 (B.). 1885, Jan. 10, fine orange red (Fr.).: Dec 1, 7·5; very orange red: Dec. 17, very red. 1886, Nov. 21, 7·0; orange red (Es.).
154	”	"Cape obs.: vivid sanguine red, a superb specimen of its class."—*Addit. obs.:* 1882, Dec. 4, red; Pechüle. A. G. C., 7½; red.
155	”	"Hind, 3 Sept., '48; very red: 14 Nov. '59; bluish"—*B.'s obs.:* 1876, Jan. 21, not seen.—*Addit. obs.:* 1876, Jan. 1, 8·5; pale yellow: Feb. 5; pale orange (C.). 1879, Jan. 8, 8·5; red: Jan. 11, 8·7; orange (D.). 1888, Jan. 10, 9·2; white (Es.).
156	Espin, . . .	56. 1885, Oct. 27, 9·0; red; colour very fine: Nov. 5, very red; 9·5; one of a little triangle: Nov. 16, 17, 28: Dec. 13, 8·5; very red.
157	Webb, . . .	(Private letter); 9·5; pale red.—*Addit. obs.:* 1888, Jan. 10, 9·0; red (Es.).
158	*Schj.'s notes*, .	"D'Arrest (28 March, '68); dunkelroth; 9·5."—*B.'s obs.:* 1876, March 13, pale red; 8·5.—*Addit. obs.:* 1876, Feb. 4, 7·9; full red: Feb. 19, 9·0; full red (C.) 1879, Jan. 15, 8·5; reddish (D.). 1885, Nov. 16, 8·5; red: Dec. 1, 8·5; orange red: 1886, Nov. 30, 8·0; red. 1887, Feb. 8, 8·2; red, *var.* (Es.). Knott (private letter); red.
159	Burton, . .	(Private letter); ruby; 10.—*Addit. obs.:* in centre of cluster. 1888, Jan. 9, 9·0; pale red (Es.).
160	Burton, . .	(Private letter); strong red; double; 8 and 9; 190°; 0″·7.—*Addit. obs.:* 1888, Jan. 9, no red star here, and no double star seen (Es.).
161	Webb, . . .	(Private letter); red; 9.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
162	126	—	D. M. + 10°. 927,	v.^{h} 48^{m} 8^{s}	+ 3^{s}·32	+ 10° 33′·5	+ 0′·02	6·5
163	—	—	. . . .	49 17	3·56	+ 20 9·2	0·01	var.
164	—	—	A. G. C., 7033, .	52 46	2·73	− 14 13·3	0·01	8·0
165	131	68	. . . .	55 11	3·08	+ 0 12·3	0·01	—
166	132	69	. . . .	55 32	3·08	+ 0 15·9	0·01	—
167	—	—	η Columbæ, . . .	55 47	1·83	− 42 49·3	0·01	4·0
168	133	70	. . . .	56 44	2·95	− 5 18·3	0·01	6·5
169	134	71	. . . .	56 52	3·08	+ 0 14·6	+ 0·01	9·5
170	—	—	D. M. − 21°. 1353,	vi. 2 18	2·54	− 21 47·9	− 0·00	6·1
171	—	—	19 Leporis, . . .	2 54	2·61	− 19 9·3	0·00	5·8
172	135	72	. . . .	4 3	3·72	+ 26 2·1	0·01	7·4
173	136	—	D. M. + 21°. 1146,	5 15	3·61	+ 21 53·7	0·01	7·3
174	137	—	D. M. + 22°. 1220,	5 40	3·63	+ 22 55·8	0·01	6·7
175	138	73	. . . .	6 38	3·76	+ 27 11·8	0·01	9·0
176	—	—	1 Lyncis, . . .	7 49	5·54	+ 61 31·4	0·01	5·5
177	—	—	D. M. + 33°. 1290,	10 0	3·95	+ 33 14·6	0·01	9·1
178	141	—	D. M. + 39°. 1576,	10 5	4·17	+ 39 30·5	0·01	6·9
179	II. No. 3.	—	D. M. − 16°. 1426,	12 48	2·67	− 16 46·5	0·02	6·0
180	—	—	. . . .	15 43	4·54	+ 47 43·7	0·02	—
181	142	—	D. M. + 14°. 1247,	13 48	3·42	+ 14 41·8	0·02	5·8
182	—	—	D. M. − 11°. 1459,	15 58	2·79	− 11 46·1	0·02	6·8

No.	OBSERVATIONS.	
162	Birmingham, .	1876, Jan. 26; pale red; 7.—*Addit. obs.:* 1879, Jan. 8, 6·5; orange: Feb. 5, 6·6; orange. 1880, Feb. 8; yellow (D.). 1885, Feb. 25, 7·5; pale orange (Es.).
163	A Variable, .	Discovered by Gore. Very orange red. See Gore's Var. Star Catalogue.
164	A. G. C., . .	8½ Crimson.
165	*Schj.'s notes*, .	"Bond; reddish."—*Addit. obs.:* 1875, Nov. 7, 9·3; orange. 1876, Jan. 1, 9·3; red (C.). 1879, Jan. 3, 9·2; orange. 1880. Feb. 5, 9·5 (D.).
166	"	"Bond; red; 10. Schj., 2004; 9."—*Addit. obs.:* 1876, Feb. 4, 9·6; red: Feb. 11, 9·8; red (C.). 1880, Feb. 14, 9·3 (D.).
167	Thome, . .	(Private letter); very red.
168	*Schj.'s notes*, .	"Schm. (Acad. sternk.): gelbroth; 7. Schj., 2015–17; roth; 8. Ll., 11451; 7."—*B.'s obs.:* 1873, Feb. 2, reddish yellow: Dec. 20, reddish yellow; 7·7.—*Addit. obs.:* 1876, Jan 21, 7·8; orange: Feb. 19, reddish (C.). 1879, Jan. 8, 6·5; red: Jan. 25, 7·3; orange (D.). 1885, Feb. 27, 7½; pale red: Dec. 16, 7·5, OR′. (Es.). Schönfeld; 6·5; stark röthlich.
169	"	"Bond; red; 10."—*Dublin obs.:* Copeland; red. A faint neb., or double 3^s f., 1′ s.—*Addit. obs.:* 1879, Jan. 22, 9·2; orange (D.).
170	Pickering, .	No. 17 (A. N., 2376); red.
171	Pickering, .	No. 18 (A. N., 2376); red. Thome (private letter); red. Franks; pale orange.
172	*Schj.'s notes*,	Schwerd, A. N., 77; röthlich; 6. Ll., 11684; 8. Bessel, 1; 8·5."—*B.'s obs.:* 1873, Feb. 2, very red; 7·5. 1874, Jan. 12, very red; 7·5. 1875, Jan. 25, fine deep red; 8. 1876, March 22, fine red; 7·5.—*Webb's obs.:* 1872, March 6, fine ruby colour.—*Addit. obs.:* 1876, Feb. 4, 7·7; full red: Feb. 11, 8·0; red (C.). 1879, Jan. 11, 7·5; red: Jan. 15, 7·2; very red (D.). 1885, Feb. 5, 8·0; very fine red: Dec. 1, 8·0; orange red (Es.). 1885, Feb. 19; deep red orange (Gemmill).
173	Birmingham, .	1872, Jan. 23, red; 7.—*Addit. obs.:* 1880, Feb. 14, 6; very red (Do.). 1878, Jan. 10, 8·0; red. 1885, Feb. 5, 7·3; fine red: Nov. 20, 7·0; orange red (Es.). 1885, March 1, ruddy orange (Fr.). 1888, Jan. 19, 7·0; orange red. 1889, Jan. 30, 7·5; orange red (Es.).
174	Webb, . . .	And afterwards found independently by B. 1871, Jan. 23, fine red; 7·0; and same mag. and colour in subsequent observations.—*Addit. obs.:* 1863, Dec. 2, 7·0; fiery red (W.). 1880, Feb. 14, 6; red (Do.). 1885, March 1, orange (Fr.). 1885, Feb. 5, 7½; fine red: Nov. 20, 6·5; orange red: Dec. 13, 6·5; very orange red. 1887, Dec. 7, 7·0; orange red (Es.).
175	*Schj.'s notes*, .	"Cape obs.: ruby-coloured, 8·5. D'Arrest; dunkelroth. Bessel, 94, 95; 8·5 und 9."—*B.'s obs.:* 1873, Feb. 3, reddish; 9.—*Addit. obs.:* 1876, Jan. 21, 8·8; red: Feb. 19, 8·8; full red (C.). 1879, Jan. 16, 8·8; reddish. 1880, Feb. 5, 9·0; s. of three (D.). 1885, Feb. 5, 9·0; very pale red (Es.).
176	Dunér, . .	Rouge-jaune. D'Arrest (A. N., 2016); 6 mag. nahe farblos. Franks; fine orange.—*E.'s obs.:* 1880, April 6, 5·8; fine red orange.
177	Espin, . . .	62. 1885, Dec. 13, 8·5; very red. 1886, Nov. 3, 8·7; very red. 1888, Feb. 7, 8·5; red.
178	Birmingham, .	1873, Dec. 12, pale red; 8. 1876, May 3, a fine pale red star, 7–7·5; *var.?*—*Addit. obs.:* 1885, Feb. 5, 7·5; very pale orange. 1888, Jan. 19, 7·3; pale orange red (Es.).
179	Birmingham, .	1877, March 19, fiery red; 5·5.—*Addit. obs.:* 1885, Feb. 5, only pale orange (Fr.). A. G. C.; 5·8; yellow. 1888; Feb. 7, orange (Es.).
180	Espin, . . .	160. 1886, Nov. 24, 8·8; very red: Nov. 25, 8·5 red; *var.?* not in D. M.
181	Birmingham, .	1874, Feb. 21, fine pale orange; 7.—*Addit. obs.:* 1879, Jan. 11, 6·0; orange (D.). 1880, Feb. 14, 6; orange red (Do.). 1885, Feb. 25, 6½; fine pale orange: Dec. 16, pale orange; 6·0 (Es.).
182	Espin, . . .	242. 1886, Feb. 1, 6·5; red, with splendid light blue; 6·0 f. 1887, Dec. 17, 7·0; orange red. Found independently by Franks. 1887, Jan. 28, 7·0; orange red (private letter). Thome (private letter); 7½; red. Dunér; rouge-jaune. Schönfeld; roth.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
183	—	—	D. M. + 3°. 1214,	VI.ʰ 16ᵐ 37ˢ	+ 3ˢ·15	+ 3° 28′·8	− 0″·02	9·0
184	—	—	D. M. + 25°. 1250,	17 14	3·69	+ 25 4·2	0·02	9·5
185	—	—	D. M. − 2°. 1581, .	17 11	3·02	− 2 8·3	0·02	var.
186	—	—	D. M. − 14°. 1423,	18 19	2·72	− 14 46·8	0·03	7·0
187	144	74	. . . .	19 12	3·42	+ 14 46·9	0·03	6·5
188	145	75	. . . .	19 16	2·39	− 27 0·5	0·03	8
189	—	—	. . . .	19 44	3·53	+ 19 9·5	0·03	—
190	146	76	. . . .	24 41	3·07	+ 0 2·7	0·03	8·5
191	147	77	. . . .	24 56	3·00	− 2 56·9	0·03	7·5
192	148	78	. . . .	28 59	4·13	+ 38 32·0	0·04	6·3
193	149	79	. . . .	29 14	3·07	+ 0 6·4	0·04	9·2
194	—	—	D. M. − 1°. 1288,	29 38	3·04	− 1 25·2	0·04	8·3
195	—	—	D. M. − 5°. 1699,	30 21	2·95	− 5 18·1	0·04	9·2
196	—	—	D. M. − 12°. 1566,	32 36	2·77	− 12 52·2	0·05	6·8
197	—	—	L, 2408, . . .	35 28	1·17	− 55 14·9	0·05	7·2
198	150	80	L, 2409, . . .	35 57	1·33	− 52 50·2	0·05	7·5
199	151	79b	. . . .	36 41	2·86	− 9 3·8	0·05	5·9
200	—	—	D. M. + 3°. 1381, .	38 54	3·15	+ 3 25·6	0·06	9.3

No.		OBSERVATIONS.
183	Espin, . . .	1888, Jan. 9, 8·6 ; very red.
184	Espin, . . .	161. 1886, Feb. 1, March 9, 9·0 ; very red : Nov. 25, 9·0. 1888, Jan. 19, 9·5 *var.* ?
185	Schönfeld, .	Gelbroth, *var.* ; 7·5 < 9·5.—*E.'s obs.* : 1886, Nov. 3, 8·0 ; red.
186	Konkoly, . .	1884, March 15, 7·5 ; gelblich roth. Ll, 12254. A.G. C., 7¾.
187	*Schj.'s notes*, .	" Bessel, 492 ; roth ; 8. Cape obs. : vivid red ; 7. Ll., 1245, 46 ; 7 und 6·5."—*B.'s obs.* : 1871, March 14, orange ; 8. 1872, Feb. 10, orange ; 7·8 ; a distant blue *comes*, 285° (estim.) : Dec. 20, fine red orange ; 7. 1874, Feb. 3, fine red orange ; 6·8 : Feb. 9, fine red orange ; 7·5 : Feb. 21, same colour ; 7·3 : March 6, same colour ; 7 : March 12, 7·3 : March 18 ; 7. 1875, Jan. 25, fine red ; 7. 1876, Jan. 21, fine deep red orange ; 6·5 : Feb. 7, splendid orange ; 7 : March 22, fine red orange ; 7. This star seems decidedly *variable.*—*Webb's obs.* : 1874, Feb. 14, fine orange ruby ; 8·3.—*Addit. obs.* : 1876, Feb. 4, pale red : Feb. 11, 7·0 ; fine light red (C.). 1879, Feb. 5, 6·5 ; deep red (D.). 1880, Feb. 14, 7 ; very red (Do.). 1884, March 14, 8 ; pale orange red ; small distant blue *comes* (W.). 1885 Feb. 25, 7½ ; fine red ; *comes* ; 280° 80″, 10 mag. ; Dec. 16, red ; 6·4. 1888, Jan. 12, 6·8 ; red (Es.);
188	"	" Cape obs. : intense ruby."—*Addit. obs.* : Pechüle. 1882, Dec. 8, trés rouge. A. G. C., 8 . orange yellow. Thome (private letter) ; red.
189	Espin, . . .	243. Dec. 21, 9·4 ; very red.
190	*Schj.'s notes*, .	" Bond ; reddish ; 9·5."—*Addit. obs.* : 1876, Feb. 4, full orange : Feb. 11, 8·6 ; orange (C.). 1880, Feb. 5, 8·5 ; reddish : Feb. 14 ; 8·5 reddish (D.). 1880, Feb. 14, 8·5 ; very red (Do.).
191	"	" Schj., 2236 ; roth ; 7·7. Ll., 12481 ; 8. Bessel, 696 ; 8. Bremiker (Akad. Sternk.) ; 9."—*B.'s obs.* : 1873, Feb. 2, yellow ; 7 : a distant blue *comes*, 11, 95° (estim.) : Dec. 26, orange ; 6. 1874, Feb. 3, orange ; 5–6 : Feb. 9, orange ; 6 : March 6, pale red ; 8. 1875, Jan. 25, orange ; 6·8. 1876, Jan. 21, light orange ; 6 : March 22, fine orange ; 6, at least, *comes*, 95° ; seems decidedly variable.—*Addit. obs.* : 1876, Feb. 5, 6·5 ; deep yellow : Feb. 19, 7·0 ; deep yellow (C.). 1879, Jan. 3, 7·2 ; orange : Jan. 16, 7·5 ; orange (D.). 1883, Feb. 3, 5·5 ; light orange ; *comes* at 95° (Bm.). 1885, Feb. 27, 6½ ; reddish : Dec. 16, 8·0 ; orange red ; blue star 6′ n. (Es.). A. G. C. ; 7½ ; yellow. See Gore's Susp. Var. Star Catalogue.
192	"	" Hist. Cél., p. 208 ; rouge ; 6. Cape obs : orange red : 6·5. Secchi ; reines roth."—*B.'s obs.* : 1871, March 14, fine orange red. 1873, Feb. 2, same colour : April 11, orange, 6·5. 1875, Jan. 25, orange ; 6.—*Dublin obs.* : Copeland ; 1876, orange red ; 5.—*Addit. obs.* : 1879, Jan. 8, 6·2 ; splendid red : Jan. 15, 6·5 ; red (D.). 1885, Jan. 24, orange red, very fine (Fr.). 1886, April 15, above 6, fiery orange (Gemmill). 1878, Oct. 24, 6·0 ; red. 1885, Feb. 5, colour wonderful ; 6·0 ; followed by Σ 940, 10″ ± 9½, 11. Feb. 9, 20 ; 6·0 ; very fine red (Es.).
193	"	" Bond ; reddish ; 9·5."—*Addit. obs.* : 1876, Feb. 5, 8·9 ; deep orange : Feb. 11, 8·9 ; deep orange (C.). 1879, Jan. 22, 9·1 ; red (D.). 1880, Feb. 14, 9·5 (Do.).
194	Espin, . . .	165. 1886, Nov. 3, 8·3 ; very red. 1888, Feb. 13, 8·2 ; orange red.
195	Espin, . . .	245. 1887, Dec. 11, 8·5 ; very red.
196	Webb, . . .	1880, Dec. 30, 7 ; orange : a glorious object.—*E.'s obs.* : 1888, Jan. 26, 6·7 ; pale orange red.
197		h. 3884. Russel (private letter), 7 ; red.
198	*Schj.'s notes*, .	" Moesta, obs., p. 103 ; de color rojizo."—*Addit. obs.* : Pechüle. 1882, Dec. 8, deux étoiles de couleur rouge-jaune.
199	"	" Santini ; rossa. Bessel, 1064."—*Addit. obs.* : 1876, Feb. 5, 5·7 ; fine yellow : Feb. 11, 6·1 ; very deep yellow (C.). 1879, Jan. 3, 5·5 ; pale orange ; Jan. 16, 5·5 ; orange (D.) 1885, Feb. 27, 6·0 ; pale reddish orange (Es.). U. A., 5·7 ; red ; Schönfeld, röthlich.
200	Pickering, .	No. 21 (A. N., 2376), 11 mag. ; very red. Dunér ; rouge-jaune foncé.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
201	—	—	. . . .	VI.^{h} 41^m 56^s	+ 3^s·09	+ 0° 48′·1	− 0′·06	—
202	153	81	. . . .	42 14	2·58	− 20 39·5	0·06	neb.
203	—	—	D. M. − 14°. 1597,	43 50	2·74	− 14 16·0	0·06	8·0
204	155	82	. . . .	45 14	3·07	+ 0 3·2	0·06	9·5
205	—	—	. . . .	46 59	2·91	− 7 0·5	0·07	—
206	—	—	D. M. − 4°. 1708, .	47 45	2·97	− 4 26·6	0·07	9·0
207	159	82*a*	R Lyncis, . . .	52 13	4·97	+ 55 28·9	0·07	var.
208	—	—	D. M. + 6°. 1462, .	52 30	3·22	+ 6 18·8	0·08	8·0
209	161	84	L. 2557, ...	53 20	1·60	− 48 34·6	0·08	5·5
210	—	—	D. M. − 16°. 1686,	53 39	3·67	− 16 59·8	0·08	8·6
211	—	—	D. M. − 3°. 1685, .	55 31	3·00	− 3 6·1	0·08	7·7
212	—	—	D. M. − 12°. 1740,	56 27	2·77	− 12 58·5	0·08	8·2
213	162	85	σ Canis Majoris, .	57 20	2·39	− 27 46·6	0·08	3·6
214	163	86	. . . .	57 29	2·88	− 8 17·6	0·08	neb.
215	164	87	R Geminorum, . .	VII. 0 44	3·62	+ 22 52·7	0·09	var.
216	165	88	. . . .	1 47	2·91	− 7 23·3	0·09	8·3
217	167	88*b*	R Canis Minoris, .	2 40	3·30	+ 10 11·6	0·09	var.
218	166	89	. . . .	2 55	2·80	− 11 45·0	0·09	7·6
219	—	—	. . . .	8 54	2·87	− 9 3·9	0·10	8·5
220	170	91	. . . .	8 59	3·59	+ 22 9·4	0·10	7·2

No.	OBSERVATIONS.	
201	Espin, . . .	63. A remarkably red star; 9·6; several obs., 1885–1888.
202	*Schj.'s notes*, .	"h. 411 (= M. 41). The chief 8-mag. star is red."—*B.'s obs.:* 1873, Dec. 26, a pale red; 8, in cluster. Webb sees five reddish stars here, 8–9 mag.—*Addit. obs.:* 1876, Feb. 5, 7·6; orange: Feb. 11, 8·2, orange: March 4, 7·8; light red (11^{s}·4 f. 1′ n.; an 8·3 deep yellow) (C.). 1879, March 7, 8·0; red (D.). 1888, Jan. 26, 7·3; reddish *var.* ? (Es.).
203	A. G. C., . .	Crimson; 8.
204	,,	"Bond; fine red; 10."—*Addit. obs.*; 1876, Feb. 19, 8·9; full orange: March 10, 8:9: full red (C.). 1879, Jan. 16, 9·0; orange; n. f. of two; other 9·7 (D.). 1885, Dec. 16, 8·3; very red: Dec. 17; 8·8; red: 1889, Jan. 29, 9·0; orange red (Es.).
205	Espin, . . .	247. 1887, Dec. 11, 8·8; very red: Dec. 14, same: splendid field.
206	Holden, . .	93. 1882, Feb. 22, 24, 8·7; orange red.—*E.'s obs.:* 1886, Nov. 21, 8·5; very red. 1887, Dec. 11, 8·3; very red.
207	*Schj.'s notes*, .	"Schönfeld Cat.; anscheinend röthlich." See Gore's Var. Star Catalogue.
208	Espin, . . .	168. 1886, Nov. 30, 7·5; very orange red. 1887, March 22, 8·0; red. 1888, Jan. 9, 8·2; red.
209	*Schj.'s notes*, .	"Moesta; color rojizo."—*Addit. obs.:* Pechüle. 1882, Dec. 7, 5·5; orange.
210	Webb, . . .	1885, Feb. 18, 10; pale ruby; a 10·5 blue, 3′–4′ p. Copeland; red, with banded spectrum.—*E.'s obs.:* 1888, Jan. 26, 8·3; orange red: Feb. 13, 8·3; reddish.
211	Espin, . . .	64. 1885, Dec. 16, 8·0; red. 1886, Nov. 3, 7·7; red: Nov. 21, orange red. 1887, Dec. 9; 8·0; very red.
212	Konkoly, . .	1884, March 20, gelblich roth; 7·5.
213	*Schj.'s notes*, .	"Piazzi, 320; subrubei coloris; 3·5. Arg., 6085; 86; 5 und 4. Secchi, goldgelb." Schmidt, A. N., 1902; very red; 5·4.—*B.'s obs.:* 1873, March 14, 15; deep orange.—*Addit. obs.:* Pechüle; 1882, Dec. 7, jaune. U. A., 3·6; very red. H. P., 3·5.
214	,,	"h. 425 (= M. 50). Has a red star, 8·5 mag., S. of more compressed part. D'Arrest (*sid. neb.*, p. 89); rubida. Bessel, 1728; 8."—*B.'s obs.:* 1873, Feb. 2, pale reddish tinge, in neb. 8·5.—*Webb's obs.:* 1874, March 2, pale ruby; 8·5.—*Addit. obs.:* 1876, March 4, 7·9; full red (C.). 1879, Jan. 11, 8·2; reddish: Jan. 16, 8·4; red (D.). 1882, Feb. 22, 24, March 13, not seen (H.). 1885, Feb. 27, 8½; pale red. 1888, Jan. 26, 7·8; pale orange red; *var.* ? (Es.).
215	,,	"Radcl., obs., xv.; red. Auwers, A. N., 1238; blassroth. Vogel, A. N., 2000; röthlich und hellroth."—*B.'s obs.:* pale red; 6; date uncertain; 1873. See Gore's Var. Star Catalogue.
216	,,	"Bessel, 1881; roth; 8. Bremiker (Akad. Sternk.); 9."—*B.'s obs.:* 1872, Feb. 1, 1873, March 12, fine red; 8. 1876, March 13, fine red; 8.—*Webb's obs.:* 1874, March 25, pale ruby; 8·5.—*Addit. obs.:* 1876, Feb. 19, 9·1; red (Haze) (C.). 1879, Jan. 8, 7·7; red: March 1, unmistakably red; 8·0 (D.). 1885, Feb. 27, 8½; remarkably fine red. 1887, Dec. 14, 8·2; very red (Es.). A. G. C., 8; red.
217	,,	"Schönfeld, Cat.; sehr roth." See Gore's Var. Star Catalogue.
218	,,	"Hist. Cél., p. 271; rouge; 7·5. Arg., röthlich. Santini; rossa."—*B.'s obs.:* 1872, Feb. 1, pale red; 7·5.—*Webb's obs.:* 1874, March 7, orange; 8·5. Copeland; p. Schj., 89, 3′ s., is a red; 9.—*Addit. obs.*; 1876, March 10, 7·4; full red (C.). 1879, March 7, 7·8; reddish (D.). 1885, Feb. 27, 8·0; very fine red; Copeland's star is 9·0, pale red: Dec. 16, 7·0; red. 1887, Dec. 14, 7·0; very orange red (Es.).
219	Holden, . .	96. 1882·15, red; 9: Bessel (8).—*E.'s obs.:* 1888, Jan. 28, 8·0; orange red: Feb. 10, 8·5; red.
220	*Schj.'s notes*, .	"Radcl., obs., xv.; very red; 7·3; several obs. Ll, 14038; 7·5. Bessel, 204 ; 7. Secchi. röthlich."—*B.'s obs.:* 1872, Feb. 1, scarcely tinged with red; 7·5–8 (in field of finder with δ Geminorum). 1873, Jan. 24, larger and redder than before; 7–7·5, also April 18, Dec. 20, 26; orange; flushed red; 7·5. 1876, Jan. 25, very light red; 7·7; a distant *comes;* 11; 265° (estim.).—*Addit. obs.:* 1876, Feb. 5, 7·9; full yellow; March 4, 7·8; pale orange (C.). 1879, Jan. 8, 7·5; pale red: Jan. 16, 7·1; pale orange (D.). 1880, Feb. 14,

N	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
220	170	91	. . . .	VII.^{h} 8^{m} 59^{s}	+ 3^{s}·59	+ 47° 9′·4	– 0′·10	7·2
221	169	90	. . . .	9 7	5·21	+ 59 6·1	0·10	7·7
222	—	—	L, 2682, . . .	10 25	2·43	– 26 50·5	0·10	6·5
223	—	—	Ll, 14200, . . .	11 58	2·53	– 23 7·3	0·10	5·0
224	171	—	π Puppis, . . .	13 15	2·12	– 36 54·0	0·10	2·7
225	—	—	D. M. + 25°. 1641,	13 54	3·67	+ 25 11·6	0·11	9·2
226	172	92	. . . .	15 46	2·85	– 10 10·8	0·11	neb.
227	173	93	. . . .	16 48	3·01	– 2 43·5	0·11	9·1
228	174	—	. . . .	16 46	2·34	– 20 41·2	0·11	—
229	175	94	. . . .	18 27	2·47	– 25 33·4	0·11	7·0
230	—	—	D. M. – 2°. 2101,	19 43	3·01	– 2 55·7	0·11	9·0
231	—	—	D. M. + 46°. 1271,	20 12	4·38	+ 46 11·3	0·11	6·7
232	176	—	. . . .	21 2	2·60	– 20 44·3	0·11	8·0
233	177	94*a*	. . . .	22 40	3·56	+ 21 9·8	0·11	8·0
234	178	—	. . . .	24 9	2·85	– 10 6·0	0·12	5·5
235	—	—	D. M. + 24°. 1686,	25 14	3·64	+ 24 44·6	0·12	8·2
236	—	—	D. M. + 0°. 1977, .	26 3	3·09	+ 0 41·3	0·12	8·2
237	180	95	S Canis Minoris, .	26 45	3·26	+ 8 33·0	0·12	var.
238	II. No. 6.	—	. . . .	28 45	2·76	– 14 17·2	0·12	5·8
239	—	—	D. M. – 0°. 1765, .	30 35	3·06	– 0 16·4	0·13	9·0
240	—	—	D. M. + 2°. 1715, .	30 45	3·11	+ 2 18·9	0·13	9·3
241	—	—	D. M. + 5°. 1726, .	31 30	3·19	+ 5 38·9	0·13	8·0
242	—	—	74 Geminorum, .	33 10	3·47	+ 17 55·8	0·13	5·4

No.	OBSERVATIONS.	
220	*continued*—	6·8 ; pale red (Do.). 1885, Feb. 5, yellow ; distant *comes*, 260° ±. 1888, Feb. 7, 8·0 ; very pale red (Es.).
221	„	" Struve, obs., Dorpat. II., p. 76 ; rubra ; 7."—*B.'s obs.:* 1873, Feb. 3, 6, 8. 1874, Jan. 12, not seen as a red star : Jan. 13, blue or bluish white ; found white at Greenwich, Jan., 1874. Secchi (Mem. II., p. 41) ; " bella gialla." Spect. cont. with nothing remarkable. The star is probably variable in colour if not in magnitude.—*Addit. obs.:* 1876, Feb. 19, 7·8 ; yellow (C.). 1879, Feb. 5, 7·3 ; orange. 1880, March 19, 7·5 ; yellowish (D.) : 1880, April 6, 7·0 ; pale red (Do.). 1878, Jan. 28, 6½ ; orange red (Fr.). 1888, March 10, the star is 8 ; white. There is a yellow orange 6·5, 1^{m} 12^{s}·8 f. + 20′·8 n (Es.).
222	Thome, . .	(Private letter) ; 6·5 ; very red.—*E.'s obs.:* 1888, Jan. 26, 6·5 ; orange.
223		h. 3945. A. 7 ; orange ; very high yellow ; B. 8 ; pale blue ; contrasted blue. Webb (C. O., p. 260), 6·5, 8 ; fiery red, greenish blue. Gore (private letter), 1875, red, blue. Birm., 1879, Jan. 22, 8·5 red, 9 blue. Espin, No. 65 ; 1884, Feb. 10, 6·5 ; red ; 7·0, remarkably blue. 1885, Dec. 1, 7·0, orange ; 8·0 blue, very fine. Large star probably *var.* A. G. C., 5½, 7. Schönf., 5·0, 7·0. H. P., 4·7.
224	Schmidt, . .	(A. N., 1902), No. 37 ; very red.—*Addit. obs.:* Pechüle ; 1882, Dec. 8, trés rouge-jaune. Gore (private letter) ; beautiful orange.
225	Espin, . . .	248. 1886, March 9, 9·0 ; fine red. 1887, March 3, 8·7 ; red : Dec. 17, 8·7 ; red : Dec. 21, one of a triangle ; other stars, 9·5 ; 9·2 ; (D. M., mag. 9·2, 9·0), at least 8·2. 1888, Jan. 19, 8·8 ; red ; var. ?
226	*Schj.'s notes*, .	" h. 443 ; the p. star is red."—*Addit. obs.:* 1880, Feb. 5, March 7, no red star seen (D.). Earl of Rosse : 1856, Jan. 30, does not look red.
227	„	" Schj. (note zu 2657) ; blutroth ; 9. Ll., 14347 ; 9·5. Bessel, 452 ; 9."—*B.'s obs.:* no red star seen several obs.—*Addit. obs.:* 1876, Feb. 5, 9·3 ; reddish, 3′ n. of a blue star : Feb. 11, 8·9 ; orange (C.). 1888, Feb. 10, 9·0 ; colourless (Es.):
228	Webb's C. O.,	3rd edition, p. 267 ; red.—*Addit. obs.:* 1882, Dec. 7, not seen (Pechüle). 1888, Feb. 13, not seen (Es.).
229	*Schj.'s notes*, .	" Cape obs. : intense red ; 7 ; 1st Arg. z. 360. Nr. 149."—*B.'s obs.:* 1873, March 14, pale red.—*Addit. obs.:* 1876, March 10, 8·0, very deep orange (C). 1879, Jan. 8, 7 ± reddish : March 1, 7·0 (D.) 1882, Dec. 7, rouge-jaune (Pechüle). A. G. C., 7¼ ; red.
230	Espin, . . .	249. 1887, Dec. 9, 8·8 ; red. The place in A. N. 2825 is in error.
231	Espin, · . .	171. 1886, Nov. 22, 8·0 ; red : Nov. 25, 7·5 ; very orange red, *var.* ? 1888, Feb. 7, 7·8 ; red.
232	Burnham, . .	M. N., XXXVI., No. 7 ; large star red ; 8. Ll., 14503.—*Addit. obs.:* 1882, Dec. 7, 8·0 ; rouge-jaune (Pechüle). 1888, Feb. 13 ; red ; 7·7 (Es.). A. G. C., 8½.
233	*Schj.'s notes*, .	" D'Arrest (Resultate) ; blassröthlich. Derselbe (*sid. neb.*, p. 91) ; non diutius rubicunda.—*Addit. obs.:* 1876, March 4, 7·8 ; full yellow : March 22, 7·7 ; deep yellow (C.). 1880, Feb. 14, 8·2 ; no colour : March 7, 8·2 ; not red (D.). 1880, Feb. 14, hardly red (Do.).
234	Birmingham, .	1875, Feb. 14, fine orange red ; 7. Ll., 14599. *Probably var.*—*Addit. obs.:* 1882·15, orange red ; 7 (H.). A. G. C., 6·2. Schönfeld ; rothgelb.
235	Espin, . . .	195. 1887, March 3, 8·0 ; red : March 23, 8·7 ; red. 1888, Jan. 19, 8·0 ; red.
236	Bond, . . .	8½, very red.—*E.'s obs.:* 1888, Feb. 10, 8·3 ; very pale red.
237	*Schj.'s notes*, .	" Hind ; fiery red ; 8·5. Winnecke, A. N., 1224 ; stark roth. Vogel, A. N., 2000 ; roth." See Gore's Var. Star Catalogue.
238	Birmingham, .	1877, March 19, fiery red ; 6. Ll., 14776.—*Addit. obs.:* 1885, Feb. 18, fine pale orange (Fr.). A. G. C., 5·2.
239	Konkoly, . .	1884, Feb. 21, 7 ; gelblich roth. *E.'s obs.:* 1888, Jan. 28, no 7 mag. here.
240	Espin, . . .	175. 1886, Nov. 29, 8·8 ; red, with blue *comes* 10 mag. 1888. Jan. 28, 9·0 ; very red.
241	Webb, . . .	1874, March 26, 8 ; pale ruby : April 20, 9.—*E.'s obs.:* 1888, Feb. 10, 8·0 ; red.
242	Vogel, . . .	1881, April 20, gelblich roth. Franks, 6 ; pale orange.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
243	II. No. 7.	—	. . . .	VII.^{h} 34^{m} 26^{s}	+ 2^{s}·71	− 16° 35′·7	− 0′·13	6·3
244	—	—	U Canis Minoris, .	35 22	3·25	+ 8 38·2	0·13	var.
245	184	97	S Geminorum, . .	36 26	3·61	+ 23 42·6	0·13	var.
246	185	97*a*	R Puppis, . . .	36 37	2·33	− 31 24·4	0·13	var.
247	—	—	D. M. + 39°. 1996,	36 45	4·06	+ 39 6·2	0·14	7·7
248	186	97*b*	. . . .	37 5	2·84	− 10 37·4	0·14	8·6
249	187	—	D. M. + 5°. 1759, .	37 32	3·18	+ 5 12·2	0·14	7·1
250	190	100	. . . .	42 14	2·32	− 31 52·6	0·14	9¼
251	191	99	T Geminorum, . .	42 42	3·61	+ 24 0·3	0·14	var.
252	—	—	D. M. + 5°. 1797,	42 55	3·19	+ 5 41·8	0·14	9·2
253	—	—	D. M. − 13°. 2247,	44 35	2·77	− 13 48·3	0·15	7·2
254	192	101	. . . .	47 28	9·69	+ 79 46·8	0·15	—
255	193	102	. . . .	47 55	2·49	− 26 6·5	0·15	neb.
256	194	103	. . . .	53 15	1·68	− 49 41·3	0·16	8
257	—	—	. . . .	56 26	2·06	− 40 58·4	0·16	—
258	195	103*a*	. . . .	56 32	1·01	− 60 33·3	0·16	neb.
259	—	—	. . . .	55 40	2·81	− 12 32·3	0·16	var.
260	—	—	. . . .	VIII. 5 32	0·04	− 69 32·4	0·17	—
261	—	—	D. M. + 25°. 1880,	8 10	3·60	+ 25 3·9	0·17	8·4
262	197	104	. . . .	8 13	3·07	− 0 5·0	0·18	9·0
263	198	105	R Cancri, . . .	10 30	3·31	+ 12 3·6	0·18	var.
264	—	—	L, 3237, . . .	10 52	1·93	− 45 29·9	0·18	—
265	199	105*a*	V Cancri, . . .	15 27	3·43	+ 17 38·0	0·18	var.
266	200	106	. . . .	16 26	3·08	+ 0 11·4	0·19	7·9
267	201	—	L, 3300, ...	19 13	2·22	− 37 56·0	0·19	6·9

No.		OBSERVATIONS.
243	Birmingham, .	1877, March 19, red; 6. Ll., 14952. A. G. C., 7.
244	Baxendell, .	New star. 1879, Nov. 25; orange.—*B.'s obs.:* 1880, Jan. 24, faint red. Knott (M. N., XL. 2, p. 103), ruddy yellow, or orange. Vogel (M. N., XL. 5, p. 294), reddish yellow.
245	*Schj.'s notes*, .	"Hind; 1848, bluish; 1852, reddish. Winnecke, A. N., 1120, tief orange. See Gore's Var. Star Catalogue.
246	"	"h. 3094; has one red, 9 mag." The place here given is from the A. G. C. See Gore's Var. Star Catalogue.
247	Dunér, . . .	Rouge-jaune.
248	*Schj.'s notes*, .	"Santini; rossa; 7·5. Ll., 15018."—*Addit. obs.:* 1876, Feb. 11, 8·0; very deep orange (C.). 1879, Feb. 28, 8·5; orange: March 1, 8·0; red: March 8, 8·0; orange (D.). 1885, Feb. 27, 7½; yellowish (Es.). A. G. C., 8½.
249	D'Arrest, . .	Astr. Nachr., 2044 (corrected from 2032); hellroth.
250	*Schj.'s notes*, .	"Cape obs.: fine ruby colour."—*Addit. obs.:* 1883, Jan. 6, rouge (Pechüle).
251	"	"Hind; 1848, Oct., and 1852, Jan., bluish. 1848, March and Dec., reddish. 1852, Feb. 10, light orange: Feb. 25, red. Auwers, A. N., 1238; röthlich oder orange." See Gore's Var. Star Catalogue.
252	Espin, . . .	176. 1886, Feb. 25; March 6; Nov. 25, 9·0; very red.
253	Konkoly, . .	1884, Feb. 20, 7·5; gelblich roth. Ll., 15275; 6·5.—*E.'s obs.:* 1888, Jan. 26, 7·0; orange red.
254	*Schj.'s notes*, .	"Piazzi (187, note); * rubei coloris; præc. 2′ circiter temporis in eodem parallelo. Dieser stern kommt aber nicht vor in D. M."—*B.'s obs.:* a bluish white 5 mag. star here, is probably Piazzi's 187. The red not seen in 1873. A star in the position with slight red tinge, 1874, Jan. 13. 1876, Jan. 21, not seen. Knott failed to see it, 1866, June 25, and Aug. 3. Possibly *variable*.—*Addit. obs.:* 1876, March 4, 9·3; red; March 22, 9·5; reddish (C.).
255	"	"H. IV., 22; red; h. 472; red colour not seen."—*B.'s obs.:* 1873, Dec. 26, pale red; 8.
256	"	"Cape obs.; brick-red, inclining to orange."—*Addit. obs.:* 1883, Jan. 6, 8·0; rouge brique un peu clair (Pechüle). A. G. C., red.
257	Russel, . .	(Private letter); *comes*, 10; red. h. 4030.
258	*Schj.'s notes*, .	"h. 3111; orange in cluster; 8: near it a ruddy, 5 mag."—*Addit. obs.:* 1883, Jan. 6, 8; rougeâtre, 5; orange (Pechüle).
259	Pickering, .	No. 26 (A. N., 2376). Dunér; rouge jaune foncé.
260	Russel, . .	(Private letter); *comes*, 8·5; faint rose tint.
261	Espin, . . .	197. 1887, March 22, 9·0; red. 1889, Feb. 5, 8·5; red.
262	*Schj.'s notes*, .	"Bond; red; 9.5. Bessel, 140; 9."—*Addit. obs.:* 1876, Feb. 5, 9·2; yellow (C.). 1879, March 1, 8·8; red: March 8, 8·6; orange: March 12, 9·0; reddish (D.).
263	"	"Auwers, A. N., 1238; hell orange.—Schönf. Cat.; gelbroth."—*Webb's obs.:* 1874, March 19, white.
264	Russel, . .	(Private letter); *comes*, 9; red. h. 4069.
265	*Schj.'s notes*, .	"Schönf. Cat.; gelbroth." See Gore's Var. Star Catalogue.
266	"	"Bond, I., p. 253; red; 8. Bessel, 370; 9. Schwerd; 8."—*Addit. obs.:* 1876, Feb. 11, 7·8; full yellow: March 31, 8·8; deep yellow (C.). 1879, Feb. 5, 7·7; orange: March 8; orange (D.).
267	"	"Moesta, obs., p. 115; de color rojizo."—*Addit. obs.:* 1883, Jan. 5, 6·0; assez rougeâtre (Pechüle).

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
268	I. No. 37.	—	L, 3304, ...	VIII.^{h} 20^{m} 19^{s}	2^{s}·59	− 23° 41′·4	− 0′·19	5·8
269	202	108	. . . .	25 48	3·07	+ 0 7·4	0·20	—
270	203	109	. . . .	26 1	3·08	+ 0 11·2	0·20	8·5
271	204	110	U Cancri, . . .	29 28	3·45	+ 19 16·3	0·20	var.
272	—	—	D. M. + 0°. 2335, .	29 30	3·08	+ 0 43·4	0·20	7·3
273	205	—	. . . .	33 43	2·70	− 19 21·1	0·20	6·7
274	—	—	D. M. + 78°. 293, .	36 11	8·21	+ 78 34·0	0·21	6·5
275	206	112	. . . .	40 52	2·53	− 27 48·1	0·22	9½
276	—	—	. . . .	40 52	2·88	− 10 25·7	0·22	6·9
277	207	111	. . . .	41 8	3·07	+ 0 2·9	0·22	—
278	208	113	. . . .	46 14	1·96	− 47 57·4	0·22	8½
279	209	114	. . . .	47 5	3·43	+ 19 44·2	0·22	8·2
280	210	114*a*	S Hydræ, . . .	47 50	3·13	+ 3 28·8	0·22	var.
281	211	115	. . . .	49 11	3·39	+ 17 38·5	0·23	6·5
282	212	—	60 Cancri, . . .	49 55	3·28	+ 12 3·5	0.23	5·8
283	213	116	. . . .	50 0	2·88	− 10 57·2	0·23	6·8
284	215	117*a*	T Hydræ, . . .	50 19	2·92	− 8 41·4	0·23	var.
285	214	117	T Cancri, . . .	50 24	3·44	+ 20 16·4	0·23	var.
286	—	—	. . . .	54 ::	::	− 55 7::	::	—
287	216	118	. . . .	IX. 0 30	1·79	− 53 38·3	0·24	9·0

No.	OBSERVATIONS.	
268	Smyth, . .	1830, red; 1851, orange. Santini; 1846, orange red. *Webb's obs.*: 1852, March 8, red. 1888, Feb. 10, 6·7; orange red (Es.).
269	*Schj.'s notes*, .	"Bond; reddish; 11·5."—*Addit. obs.*: 1876, March 10, 10·2 (C.).
270	„	"Bond, I., p. 243; orange; 10. Ll., 16770; 9·5. Bessel, 625; 9. Schwerd (Akad. Sternk.); 8. Schj., 3122; 8·7."—*Addit. obs.*: 1876, Feb. 5, 8·1; full yellow (C.). 1879, Feb. 5, 8·3: March 8, 7·8; an 8·8 n. p.: March 12, 8·5; orange (D.).
271	„	"Winnecke, A. N., 1224; keine färbung. Auwers, A. N., 1238; röthlich. Schönfeld Cat. rothlich." See Gore's Var. Star Catalogue.
272	Bond, . . .	8, reddish.—*E.'s obs.*: 1888, Feb. 10, 8·2; flushed.
273	Burnham, . .	M. N., XXXVI., No. 7, decidedly reddish. Ll., 17091.—*Addit. obs.*: 1882·15, 6·5; orange red (H.). A. G. C., 7.
274	Dunér, . .	Rouge-jaune.
275	*Schj.'s notes*, .	"Cape obs.: fiery red; 8·5. Argel., 8952; 8·5."—*Addit. obs.*: 1883, Jan. 5, 8·5; rouge (Pechüle). A. G. C., 9¼; orange red.
276	Dunér, . .	Rouge-jaune.—*E.'s obs.*: 1887, Feb. 23, 7·0; orange red, with pale orange red; 6·0, 10′ s. (Wendell, A. N., 2376, Type III. Dunér; jaune-rouge).
277	*Schj.'s notes*, .	"Bond, I., p. 245; orange red; 8. Schj., 3228; 8."—*Addit. obs.*: 1876, Feb. 19, 8·6; full red (C.). 1879, Feb. 25, 8·2: March 8: orange (D.).
278	„	"Cape obs.: ruby-coloured."—*Addit. obs.*: 1883, Jan. 6, 8·5; assez rouge (Pechüle). A. G. C., 8¾; orange.
279	„	"D'Arrest; subrubra; 9. Ll., 17497, 98; 9 und 8."—*B.'s obs.*: 1873, Feb. 6, 8, reddish; 8·5; Dec. 26, reddish; 8·5–9.—*Addit. obs.*: 1876, Feb. 1, 8·7; full orange: Feb. 11, 7·2; pale orange (C.). 1879, March 12, 8·0; orange (D.). 1880, Feb. 14, 8; slightly red (Do.). 1885, Feb. 17, 9 mag.; fine red (Es.).
280	„	"Schönf. Cat.; röthlich gelb." See Gore's Var. Star Catalogue.
281	„	"Ll.; 6·5; rouge. Cape obs.: fine red; brick red; 8·5. T. Mayer, 380, 7. Ll., 17576; 6·5. Chacornac; 6. Birmingham; 7 bis 7·5."—*B.'s obs.*: several since those quoted by Schj. from A. N., 1843; colour varying in different degrees of red and orange; 7–7·5.—*Webb's obs.*: 1872, March 5, rather pale ruby; 8.—*Addit. obs.*: 1876, Feb. 5, 6·8; orange red: March 22, 6·9; orange (C.). 1879, Feb. 23, 6·5; fine orange red: March 8, deep orange (D.). 1880, Feb. 14, 6·6; fiery red (Do.). 1882·11; 8; orange red (H.).—*Gage's obs.*: 1881, Dec. 20, 6·5; fiery red: Dec. 21, 6·8: Dec. 22, 7·0. 1882, Jan. 3, 6·5: Jan. 21, 6·3: Feb. 15, 6·7: March 15, April 14, 6·7.—*E.'s obs.*: 1882, Feb. 2, 6·4 (D. M., 17°. 1979, $1^m\ 45^s$ f. 10′ s. = 6·8). 1885, Feb. 9, 6·8: Feb. 17, 6·5: Dec. 16, 6·5: 1887, Jan. 29, 6·5. The star is probably a variable of the 19 Piscium type.
282	Webb, . . .	1874, March 19, pale orange; 8. Found independently by Birm. as pale orange red; 8.—*Addit. obs.*: 1880, April 27, May 17, 5; red orange, certainly variable (Birm.). 1885, Feb. 9, fine pale orange; 6·5: Feb. 17, May 7, 6½; orange: Dec. 16, 6·3 (Es.). 1885, Dec. 2, 6·0; orange (Gemmill), H. P., 5·7. See Gore's Susp. Var. Star Catalogue.
283	*Schj.'s notes*, .	"Schj.; roth; 8. Ll., 17624; 6·5. Bessel, 1249; 7·5."—*B.'s obs.*: an 8 mag., pale yellow, is followed by a 7·5 mag. of higher colour. This is followed by a blue 8 with a *comes*, 9·5. The 7·5 seems to be Schj.'s star. 1873, Feb. 6, 8; faint red; 7·3: April 1, and Dec., pale red; 7·3.—*Dublin obs.*: Copeland; 1876, March 21, pale orange.—*Addit. obs.*: 1876, March 10, 7·7; second of 3 (C). 1879, March 19, deep orange. 1880, March 7, 7·8; orange: March 19, 8·0; yellow (D.).
284	„	"Schönf. Cat.; stark gelbroth." See Gore's Var. Star Catalogue.
285	„	"Bessel, 1200; roth. Winnecke, A. N., 1224; blutroth. Arg. VI., p. 110; sehr roth." See Gore's Var. Star Catalogue.
286	Russel, . .	(Private letter); after h. 4156; 7 mag.; red.
287	*Schj.'s notes*, .	"Cape obs.: ruby-coloured."—*Addit. obs.*: Pechüle, 1886, Jan. 6, assez rouge; 9·0. A. G. C., 8¾; orange red.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
288	217	119	κ Pyxidis, . . .	IX.^{h} 3^m 13^s	+ 2^s·63	− 25° 25′·0	− 0′·24	4·9
289	218	120	. . . .	4 0	3·64	+ 31 24·7	0·24	6·5
290	—	—	D. M. − 2°. 2814,	7 8	3·03	− 2 34·9	0·24	7·5
291	—	—	26 Hydræ, . . .	12 12	2·89	− 11 30·2	0·25	7·7
292	—	—	D. M. + 57°. 1214,	13 39	4·40	+ 57 9·9	0·25	5·8
293	221	—	D. M. + 0°. 2499,	14 58	3·08	+ 0 38·2	0·25	7·5
294	222	—	. . . .	18 1	2·73	− 21 47·5	0·25	—
295	223	—	α Hydræ, . . .	22 11	2·95	− 8 10·9	0·26	var.
296	—	—	33 Hydræ, . . .	29 3	2·99	− 5 25·4	0·26	6·7
297	225	121	R Carinæ, . . .	29 29	1·51	− 62 18·1	0·26	var.
298	—	—	D. M. − 9°. 2903,	36 5	2·93	− 10 0·1	0·27	7·2
299	227	122	R Leonis Minoris,	39 59	3·62	+ 35 1·1	0·27	var.
300	228	123	R Leonis, . . .	41 39	3·23	+ 11 56·3	0·28	var.
301	—	—	D. M. + 40°. 2261,	43 29	3·70	+ 40 8·6	0·28	7·0
302	229	124	. . . .	45 59	2·77	− 22 30·2	0·28	6·6
303	—	—	. . . .	50 ::	. . .	− 54 28::	. . .	—
304	230	125	. . . .	50 56	2·46	− 41 3·9	0·28	7·5
305	232	126	B. 2792, ...	57 34	1·90	− 59 45·8	0·29	7½
306	234	127	18 Sextantis, . .	X. 5 26	2·98	− 7 52·5	0·29	6·0
307	235	128	B. 2874, ...	7 4	2·64	− 34 46·9	0·29	7½
308	236	129	. . . .	10 42	2·01	− 60 8·5	0·30	9½
309	—	—	. . . .	25 35	1·86	− 66 8·8	0·31	9·0

No.	OBSERVATIONS.	
288	*Schj.'s notes*, .	" Arg., 9374 ; roth. Dreimal als 4, 4·5, und 5ter Gr. Secchi ; orange gelb."—*B.'s obs.:* 1873, March 15, April 1, yellow, flashing red. h. Mali redder.—*Addit. obs.:* 1876, March 10, 5·0 ; orange (C.). 1879, Feb. 22, 4·5 ; red (D.). 1886, Jan. 5, 4·5 ; orange (Pechüle). A. G. C., orange.
289	„	" Hist. Cél, p. 221 ; rouge, 6 ; p. 319 ; 5·5. Bessel, 3 ; 7. Secchi ; roth."—*B.'s obs.:* 1872, March 24, April 2, pale red ; 6. 1873, Jan. 26, pale red.—*Dublin obs.:* Copeland ; 1876, Feb. 19, orange red ; 7·1.—*Addit. obs.:* 1879, Feb. 5, 6·5 ; March 12, 6·5 ; orange (D.). 1885, May 6, 6½ ± good orange. 1886, April 17, 6 mag. ; orange (Gemmill). 1885, May 7, 6·0 ; red, but not deep (Es.).
290	Konkoly, . .	1885, March 20, 7·5 ; gelblich roth.—*E.'s obs:* 1888, Feb. 10 ; 7·5 ; very pale orange.
291	Konkoly, . .	1885, March 11, 7·5 ; gelblich roth.
292	Dunér, . . .	Rouge-jaune.
293	D'Arrest, . .	(A. N., 2044) ; hell orange ; 7.—*Addit. obs.:* 1880, Feb. 14, 6·8 (D.) Vogel ; 1880, March 16, röthlich gelb. Heller als 7·5 ; etwa 6·8. 1885, Feb. 20. 8·0 ; very pale red, var. ? 1888, Feb. 10, 7·3 ; orange red with 8·3 bluish ; 6′ n. (Es.).
294	Secchi, . .	Mem. II., p. 43 ; yellow, fine type of α Orionis, small.—*Addit. obs.:* Pechüle ; 1883, Jan. 5, not found ; Jan. 6, 8–9, un peu rougeâtre.—*E.'s obs.:* 1888, Feb. 10, no star here. Secchi's star is not in the D. M.
295	*Schj.'s notes*, .	" Sufi (middle of 10th century) ; red. The Chinese call this star the Red Bird. Perhaps it was formerly redder."—*B.'s obs.:* pale yellowish red.—*Addit. obs.:* 1878, Dec., ruddy ; 1885, Feb. 25, fine orange (Es.). 1882–85, full orange (Gemmill). 1886, March 5, brilliant orange (Fr.).
296	Konkoly, . .	1885, March 11, 6·5 ; gelblich roth.
297	*Schj.'s notes*, .	" Cape obs. : sanguine red."—*Addit. obs.:* Gould ; var., 4·3–9·0. See Gore's Var. Star Catalogue. Pechüle ; 1883, Jan. 6, rouge. A. G. C., orange.
298	Konkoly, . .	1885, March 11, 8 ; gelblich roth. A. G. C., 8.
299	*Schj.'s notes*, .	" Schönf., A. N., 1500 ; gelbroth. Cat., stark gelbroth." See Gore's Var. Star Catalogue.
300	„	" Criswick, M. N., XVII., p. 169 ; blood red. Dunkin, *ibid.*, very red."—*B.'s obs.:* 1873, Jan. 26, red with orange cast.
301	Dunér, . .	Rouge-jaune.
302	*Schj.'s notes*, .	" Argel., 10163 ; roth."—*B.'s obs.:* 1873, March 12, fine red orange, 7. 1874, Feb. 21, fine red orange ; 7.—*Addit. obs.:* 1876, March 22, 6·8 ; full red (C.). 1879, Feb. 15, 7·0 ; orange : Feb. 22, 6·3 ; red (D.). 1885, Jan. 5, très rougeâtre ; 6·5 (Pechüle). Schönfeld ; sehr roth. A. G. C., 7·3 ; crimson. 1888, Feb. 10, 6·8 ; very red, var. ? (Es.).
303	Russel, . .	No. 137 (private letter), 9·5 ; red.
304	*Schj.'s notes*, .	" Cape obs. : scarlet ; 7·5."—*Addit. obs.:* Pechüle ; 1883, Jan. 4, rouge. A. G. C., 7½, orange. Stone ; red.
305	„	" Cape obs. : scarlet."—*Addit. obs.:* 1883, Jan. 6, 8·5 ; rouge-brique (Pechüle). Thome ; very red.
306	„	" Hist. Cél., p. 152 ; rouge, 6. Piazzi, 5 ; 6. Ll., 19828, 29 ; 5·5 und 6. Bessel, 47 ; 6·5. Secchi, orange roth."—*B.'s obs.:* 1872, April 14, yellow ; 6. 1873, March 7, reddish yellow ; 1874, Feb. 21, 6–6·5 : April 7, reddish ; 6.—*Addit. obs.:* 1876, March 22, 7·2 ; full yellow (C.). 1879, March 12, 6·0 ; orange (D.). 1885, Feb. 25, pale orange, equal to 17 Sextantis, the star p (pale blue) (Es.).
307	„	" Cape obs. : scarlet ; 7·0."—*Addit. obs.:* 1883, Jan. 3, 7·0 ; rouge (Pechüle).
308	„	" Cape obs. : ruby red ; 9."—*Addit. obs.:* 1883, Jan. 6, 9·0 ; rouge (Pechüle).
309	Russel, . .	(Private letter) ; 149, 9 ; bright red. A. G. C., 14342, 10 mag.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
310	—	—	L. 4336, ...	x.ʰ 27ᵐ 6ˢ	+ 2ˢ·28	− 53° 9′·3	− 0′·31	9·0
311	240	130	L. 4358, ...	30 20	2·67	− 38 59·6	0·31	6·5
312	—	—	. . . .	31 ::	::	− 62 13::	0·31	9½
313	241	131	*r* Carinæ, . . .	31 22	2·29	− 56 59·3	0·31	5·5
314	242	132	U Hydræ, . . .	32 7	2·95	− 12 48·8	0·31	var.
315	243	133	. . . .	35 25	3·07	− 0 0·2	0·31	8·5
316	—	—	D. M. − 13°. 3196,	36 45	2·96	− 13 12·4	0·31	7·0
317	244	134	R Ursæ, ...	36 51	4·35	+ 69 21·2	0·31	var.
318	I. 42.	—	D. M. + 68°. 617,	37 26	4·24	+ 67 59·3	0·31	6·2
319	245	134a	*w* Carinæ, . . .	39 21	2·28	− 59 59·4	0·31	5·2
320	246	135	. . . .	40 0	2·35	− 57 29·2	0·31	8¾
321	248	136	. . . .	46 17	2·91	− 20 40·0	0·32	6·7
322	—	—	56 Leonis, . . .	50 21	3·12	+ 6 46·0	0·32	6·5
323	249	137	. . . .	54 5	2·97	− 15 45·8	0·32	6·5
324	250	138	R Crateris, . . .	55 9	2·95	− 17 44·1	0·32	var.
325	253	139	. . . .	XI. 0 3	3·07	− 0 0·1	0·32	9·5
326	225	140	. . . .	5 30	1·04	− 81 11·9	0·32	8¼
327	257	140*a*	. . . .	10 24	2·56	− 60 29·5	0·33	neb.
328	—	—	. . . .	23 17	2·88	− 42 4·1	0·33	—
329	—	—	. . . .	26 20	2·99	− 23 56·3	0·33	—

No.	OBSERVATIONS.	
310	Russel, . .	(Private letter); h. 4329; *comes* 9; brick red. A. G. C., 5¾, 8½.
311	*Schj.'s notes*, .	"Cape obs.: orange, almost scarlet. Brisbane, 3085; dusky yellow. A fine planetary disk."—*Addit. obs.:* Pickering (A. N., 2376); red. Pechüle; 1883, Jan. 3; trés rouge. A. G. C., 5·9; red.
312	Russel, . .	(Private letter); 1883·27. This is a remarkably red star, 9½. The colour is as brilliant as that of the companion to β Crucis.
313	*Schj.'s notes*, .	"Moesta obs., p. 117; de color rojizo."—*Addit. obs.:* Pechüle; 1883, Jan. 3, trés orange. A. G. C., 5·3; red.
314	"	"Hist. Cél., p. 329; rouge; 5·5. Bessel, 544; roth; 6·5. Lamont, Z. 316, orangef.; 7·5. Secchi; orange gelb. Birmingham, M. N., XXXIV., hat diesen auf Variabilität geprüft."—*B.'s obs.:* 1873, March 12, fine orange red; 6–6·5. 1874, Feb. 27, fine orange; 5 at least: March 24, splendid orange red; 6: April 7, orange red; 5: May 8, orange red, seen with naked eye; 5–5·5. 1876, April 1, orange red, 6: May 9, fine red orange, 4·5.—*Addit. obs.:* Wolsingham Observatory Circular No. 3, from six years' obs., and using all other obs. known. Period, 194^{d}·6. Var. 5·0–5·2; 6·1–6·3. See also Gore's Var. Star Catalogue. It may after all, perhaps, turn out to be a var. of the 19 Piscium type (Es.).
315	"	"Bond, p. 3; red."—*Addit. obs.:* 1881, May 14, 9; not red (H.). 1885, March 6, 9·0; reddish (Es.).
316	Holden, . .	No. 118; 1882·30, 7; orange red. A. G. C., 6.9.
317	*Schj.'s notes*, .	"Auwers, A. N., 1238; blassroth." See Gore's Var. Star Catalogue.
318	Fearnley, . .	(A. N., 2121), No. 15; red yellow, orange.—*B.'s obs.:* 1877, June 18, fine red orange.
319	*Schj.'s notes*, .	"Brisbane, 3185; red; 6. Lacaille, 4446; 5."—*Addit. obs.:* Pechüle; 1883, Jan. 3, 6·0; rouge. A. G. C., 5·2; red.
320	"	"Cape obs.: ruby-coloured."—*Addit. obs.:* Pechüle; 1883, Jan. 3, 9·0; rougeâtre. A. G. C., 8¾; red.
321	"	"Hist. Cél., p. 284, bien rouge; 6. Ll., 20918; 6·5. Argel., 10927; 6. Birmingham, M. N., XXXIV.; 1873, April 20, 7. 1874, May 8, fine red; 8."—*B.'s addit. obs.:* 1876, April 1, red; 7: April 30, ruby; 7·5. *Dublin obs.:* Copeland; 1876, March 22, brown red; 7·2.—*Addit. obs.:* 1879, Feb. 22, 6·0; copper red, most magnificent: March 19, 6·8; strong red (D.). 1881, May 15, fine full red; a star 9–10 in *p.* 90°, *s* 30″ (H.). 1885, March 7, deep red (Fr.). Schönfeld; ausserordentlich roth. A. G. C., 8; red.—*E.'s obs.:* 1885, March 6, 7½; magnificent; blood red. These obs., ranging from 6 to 8, suggest that this star may be a var. of the 19 Piscium type.
322	Vogel, . . .	(Spect. Beob.); 1882, Feb. 21, gelblich roth. D'Arrest (A. N., 2044); 7 mag.; farblos. Dunér; jaune-roth.
323	*Schj.'s notes*, .	"Argelander, 11031; roth. Secchi; hellroth."—*B.'s obs.:* slightly red; or pale orange; several obs. in several years.—*Addit. obs.:* 1876, March 22, 6·9; full yellow (C.). 1879, Feb. 22, 6·0; very pale orange: April 2, 6·0; yellow (D.). 1885, March 6, 6½; pale orange (Es.). H. P., 6·3. U. A., 6·4; red.
324	"	"Cape obs.: scarlet, Winnecke, der die variabilität endeckt hat, A. N., 1816, auffallend roth. Argel., 11046; 8·5. Birmingham; M. N., XXXIV., beobacht, ihn 1872 und 1873 von 8 ter gr.; einmal aber, 7 April, 1874, von 9·5 ter gr. Jedesmal ist die rothe farbe bemerkt."—*B.'s Addit. obs.:* 1876, March 22, red, not so deep as formerly; 8. 1876, April 1, good red; 8: April 30, crimson; 8·7.—*Webb's obs.:* 1874, March 18, very intense ruby; 9·5. See Gore's Var. Star Catalogue.
325	"	"Bond, I., p. 21; red; 9·5."—*Addit. obs.:* 1876, March 22, 10·3 (C.). 1879, Feb. 23, 9·7: March 1, 9·5; red (D.). 1881, May 14, no red star seen in this place (H.).
326	"	"Cape obs.: ruby; 8." A. G. C., 8¾; crimson.
327	"	"h. 3334; red star in centre of condensed group."—*Addit obs.:* Pechüle; 1883, Jan. 3, not seen. Not in A. G. C.
328	Russel, . .	h. 4439 (private letter); 9; ruddy. A. G. C., 5½, 8½.
329	Holden, . .	120. 1883·28; 8·2; dull orange red.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
330	—	—	D. M. – 7°. 3250,	XI.^{h} 27^{m} 12^{s}	+ 3^{s}·05	– 7° 13′·2	– 0′· 33	6·3
331	264	142	. . . .	34 34	2·62	– 71 57·0	0·33	8·5
332	265	143	. . . .	35 29	3·14	+ 25 24·7	0·33	8·4
333	II. 11	—	D. M. + 26°. 2250,	38 31	3·13	+ 25 50·7	0·33	6·2
334	—	—	μ Muscæ, . . .	42 57	2·88	– 66 13·1	0·33	5·3
335	268	143*a*	. . . .	44 38	2·93	– 56 26·1	0·33	8
336	—	—	D. M. – 10°. 3353,	45 31	3·05	– 10 35·8	0·33	8·4
337	269	—	D. M. + 4°. 2553, .	52 35	3·07	+ 4 6·5	0·33	7·5
338	271	143*b*	R Comæ, . . .	58 37	3·08	+ 19 23·9	0·33	var.
339	—	—	D. M. – 5°. 3424,	XII. 1 37	3·07	– 6 9·2	0·33	7·0
340	—	—	. . . .	3 37	3·11	– 63 12·5	0·33	7½
341	273	143*c*	T Virginis, . . .	8 58	3·07	– 5 25·4	0·33	var.
342	274	143*d*	R Corvi, . . .	13 56	3·10	– 18 38·7	0·33	var.
343	—	—	D. M. – 18°. 3368,	14 1	3·10	– 18 35·3	0·33	7·8
344	—	—	ε Crucis, . . .	15 26	3·22	– 59 47·6	0·33	4·0
345	—	—	ρ′ Muscæ, . . .	16 4	3·29	– 67 41·7	0·33	6·5
346	275	144	. . . .	16 53	3·44	– 74 53·6	0·33	9½
347	276	—	17 Virginis, . . .	16 58	3·06	+ 5 54·6	0·33	7·1
348	—	—	B. 4042, . . .	18 49	3·24	– 57 30·4	0·33	8
349	—	—	L 5138, ...	18 55	3·16	– 40 46·3	0·33	6½
350	277	145	. . . .	19 37	3·07	+ 1 22·8	0·33	8·1
351	280	146	. . . .	23 40	3·00	+ 28 54·2	0·33	9·0
352	281	148	. . . .	24 45	3·06	+ 5 1·5	0·33	8·5

No.	OBSERVATIONS.	
330	Konkoly, . .	1884, April 20, 7·5 ; gelblich roth, nach Ll. ; 6 mag. A. G. C., 6·4.
331	*Schj.'s notes*, .	" Cape obs. : fine ruby." A. G. C., 8½ ; red.
332	,,	" D'Arrest ; rubra ; 8. Ll., 22122 ; 8. Bessel, 656 ; 8. Secchi, rosenroth."—*B.'s obs.* : never more than pale red, and often not red ; 8 ; frequently observed in several years.—*Addit. obs.* : 1876, March 22, 8·9 ; pale orange (C.). 1879, Feb. 28, 8·3 ; orange : March 19, 8·0 ; no colour. 1880, March 31, 8·2 ; orange (D.). 1880, Feb. 20, 8·2 ; faint red : March 18, 8·5 ; faint red (Do.). 1885, March 6, 8½ ; sometimes a reddish look (Es.).
333	Birmingham, .	1877, April 30, pale red ; 7, with a small *comes*.—*Addit. obs.* : orange red (Do.).—*E.'s obs.* : 1888, April 13, 7·0 ; pale orange red.
334	Thome, . .	(Private letter) ; very red.
335	*Schj.'s notes*, .	" h. 3365 ; an orange-coloured 8 ; about 10′ north."—*Addit. obs.* : Pechüle ; 1883, Jan. 5, orange. A. G. C., 8 ; orange red.
336	Espin, . . .	No. 199. 1887, March 23, 8·0 ; red.
337	Webb, . . .	(Private letter) ; red ; 8. P. xi., 203.—*Addit. obs.* : 1881, May 14, yellowish red only (H.). 1885, March 6, 7½ ; very pale red. 1887, March 27, 7·5 ; pale orange red (Es.).
338	*Schj.'s notes*, .	" Schönf. Cat. ; stark röthlich." See Gore's Var. Star Catalogue.
339	Konkoly, . .	1885, May 6, 7·5 ; gelblich roth. A. G. C., 8 ; red.
340	Russel, . .	(Private letter) ; 8 ; bright orange red. A. G. C., 7½ ; red.
341	*Schj.'s notes*, .	" Schönf. Cat. ; sehr roth. Arg. vi., p. 329 ; roth." See Gore's Var Star Catalogue.
342	,,	" Schönf. Cat. ; roth." See Gore's Var. Star Catalogue.
343	Dunér, . .	Rouge-jaune. Ll., 23079 ; 8·0. A. G. C., 8½.
344	Thome, . .	(Private letter) ; very red.
345	Thome, . .	(Private letter) ; very red.
346	*Schj.'s notes*, .	" Cape obs. ; sombre red ; 8·5." A. G. C., 9½ ; red.
347	Smyth, . .	cccclxiii. ; light rose tint ; 6. ; *comes*, dusky red ; 7. Sadler ; clear pale yellow. *Comes*, red. —*Addit. obs.* : Webb ; 1851, May 19, pale rose, and, I think, bluish. 1880, March 8, 7 ; white (Do.). 1885, March 6, 7 ; yellow ; 8 ; dusky : May 7, yellowish white, and bluish (Es.). Webb's C. O., 4th Edition, Σ, greenish ; white. Bird ; white ; blue.
348	Russel, . .	(Private letter) ; h. 4521, 9 ; 9 ; both red. A. G. C., 8 ; 8.
349	Russel, . .	(Private letter) ; h. 4518, 9 ; 9 ; both red. Russell, R. A. S. Memoirs, Vol. xlvii., p. 132, gives magnitudes 8, 10. A. G. C gives 6¼, 9. Is the chief star *var.* ?
350	*Schj.'s notes*, .	" Bessell, 277 ; roth ; 7·5. Lamont, z., 93 ; rubra ; 6. Scheint sich nach Birmingham (M. N., xxxiv.) etwas zu vërandern."—*B.'s obs.* : 1872, April 15, fine red ; 7. 1874, Feb. 27, fine red ; 6–6·5 : April 10, March 8, 9 ; deep red orange ; 6–6·5. 1876, March 31, fine red orange ; 7 : April 1, red orange ; 7–7·5 : April 30, fine red orange ; 7.—*Webb's obs.* : 1874, April 20, May 8 ; deep orange ; 7.—*Addit. obs.* : my observations, 1881–86, show variations from 7·8 to 8·8 (see E. M., 1886, May 6). The star is a variable of the 19 Piscium type (Es.). See also Gore's Var. Star Catalogue.
351	,,	" Cape obs : purple. No colour in a second trial, but star probably mistaken. Bessel, 461 ; 9." —*Addit. obs.* : 1876, March 22, 9·0 ; yellow (C.). 1879, April 2, 8·7 ; pale red : May 1, 9·0 : 1880, April 4, 9·0 ; orange (D.).
352	,,	" Rosse, Phil. Trans., 1861 ; scarlet ; 9·5. Bessel, 378 ; 8·5. D'Arrest ; 1866, Dec. 8, dunkelroth."—*B.'s obs.* : 1874, May 8, no colour ; 9·5.—*Addit. obs.* : 1879, Feb. 28, 8·3 ; red ;

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
352	281	148	. . . .	XII.^{h} 24^{m} 45^{s}	+ 3^{s}·06	− 5° 1′·5	− 0′·33	8·5
353	282	147	γ Crucis, . . .	25 4	3·28	− 56 29·8	0·33	2·0
354	283	148*a*	T Ursæ, ...	31 24	2·76	+ 60 5·6	0·33	var.
355	284	149	R Virginis, . . .	32 55	3·05	+ 7 35·6	0·33	var.
356	285	150	. . . .	33 40	3·17	− 26 8·7	0·33	—
357	—	—	D. M. + 56°. 1615,	35 21	2·76	+ 56 26·7	0·33	8·2
358	286	150*a*	. . . .	35 25	3·07	− 0 0·9	0·33	9·0
359	—	—	8 (Hev.) Corvi,. .	35 33	3·12	− 12 24·6	0·32	5·3
360	—	—	70 Centauri,. . .	36 30	3·30	− 48 12·5	0·33	5·4
361	287	150*b*	. . . .	38 4	3·07	− 0 50·1	0·33	8·5
362	288	150*c*	. . . .	38 47	3·07	− 0 53·2	0·33	8·7
363	289	151	S Ursæ, ...	39 7	2·66	+ 61 41·7	0·33	var.
364	290	152	. . . .	39 57	2·83	+ 46 2·5	0·33	5·5
365	291	153	. . . .	40 59	3·46	− 59 5·6	0·33	9·0
366	—	—	D. M. − 14°. 3587,	44 1	3·14	− 14 28·8	0·33	6·8
367	292	154	. . . .	45 6	3·07	− 0 9·3	0·33	8·3
368	293	154*a*	U Virginis, . . .	45 31	3·04	+ 6 9·1	0·33	var.
369	294	155	. . . .	46 44	2·99	+ 17 40·3	0·33	6·3
370	295	154*b*	. . . .	47 8	3·53	− 59 45·5	0·33	neb.

No.	OBSERVATIONS.	
352	*continued*—	March 31, 8·0; reddish: April 17, 8·5, pale red; May 2, 8·3; red (D.). 1880, March 8, 8·3; red (Do.). 1880, May 14, 8·0; reddish (H.). 1885, May 12, 8½; fine pale red (Es.).
353	*Schj.'s notes*, .	"Noel, Observ. Math. et Phys., etc., 1710, p. 43; rubra; 2. Rümker, roth."—*Addit. obs.:* Gage; 1886, May 20, orange (fine field). A. G. C., 2·0; orange. Russel (R. A. S. Memoirs, Vol. XLVII., p. 133), pale yellow; *comes*, faint green.
354	"	"Schönf. Cath.; rothlich." See Gore's Var. Star Catalogue.
355	"	"Auwers, A. N., 1238; blassgelbroth. Schönf. Cat.; rothgelb."—*B.'s obs.:* 1882, April 15, faint red. See Gore's Var. Star Catalogue.
356	"	"h. 3404; red; 12."
357	Espin, . . .	1888, Jan 26, 8·2; very red.
358	*Schj.'s notes*, .	"Bond, I., p. 33; red; 8·5. Bessel, 557; 9. Schj., 4570; 9."—*Addit. obs.:* 1876, March 22, 9·1; red (C.) 1879, March 31, 9·0; orange. 1880, April 4, 9·0; reddish: May 4, reddish (D.). 1881, May 14, no red star in this place (H.). 1865, May 12, 9·0; reddish. 1887, March 27, 9·3; orange (Es.).
359	Konkoly, . .	1885, May 12, 7; gelblich roth Σ. 1669; 6·5; yellowish white. A. G. C., 6½.
360	Thome, . .	(Private letter); very red.
361	*Schj.'s notes*, .	"Copeland (handschriftliche note); red. Ll. 23736; 8·5. Bessel, 607; 9. C. und B., 3866, '7."—*Addit. obs.:* 1879, April 2, 8·7; orange: April 17, 8·8; orange (D.). 1885, May 12, 9·0; reddish. 1887, March 27, 8·5; orange (Es.).
362	"	"Copeland (handschriftliche note); red. Ll., 23750; 8·5. Schj., 4590; 8·5. C. und B., 3870, '1."—*Addit. obs.:* 1876, March 22, 8·8; full orange (C.). 1879, April 24, 8·7; pale orange; May 2, 8·8; orange (D.). 1881, May 14, no red star in this place (H.). 1885, May 12, 9·0; reddish. 1887, March 27, 8·8; orange (Es.).
363	"	"Schönf. Cat.; intensiv rothgelb." See Gore's Var. Star Catalogue.
364	"	"Hist. Cél., p. 385; rouge. D'Arrest; rubra. Schm., A. N., 1952; sehr roth; vielleicht var. Secchi; roth."—*B.'s obs.:* 1872, March 24, orange; 6: April 15, splended orange; 4·5: May 9, 6–6·5. 1873, April 25, fine orange; 6. 1874, Feb. 18, 19; fine orange; 6; May 8, fine orange; 6. 1875, May 15, 26; splendid orange; 5; easy to naked eye. 1876, March 31, orange, not very deep; 5.—*Addit. obs.:* 1879, April 25, 5·5; deep orange brown. 1880, March 31, 5·0; deep red. 1880, April 27, 5·5; deep red (D.). 1880, Feb. 20, 5·5; very red (Do.). 1884, June 15, 5·2; fiery orange (Gemmill). 1885, April 2, splendid orange (F.). 1885, May 12, fine orange; 5·7. 1887, Feb. 26, 5·3; very orange red; possibly a variable of the 19 Piscium type (Es.). See Gore's suspected Var. Stars.
365	"	"Cape obs.: most intense blood red. In field with β Crucis; 8·5. Several obs."—*Addit. obs.:* Pechüle; 1883, Jan 6, assez rouge; 8·5. A. G. C., 9; red.
366	Konkoly, . .	1885, May 12, 7; gelblich roth. Ll., 23904.
367	*Schj.'s notes*, .	"Bond, I., p. 265; red; 9. Ll., 23938; 8·5. Bessel, 736; 8·5."—*Addit. obs.:* 1876, March 22, 8·7; very deep orange (C.). 1879, March 31, 8·2; pale orange. 1880, May 4, 8·2; orange (D.). 1881, May 14, no red star in this place (H.).
368	"	"Schönf. Cat.; röthlich." See Gore's Var. Star Catalogue.
369	"	"D'Arrest; sub-fusca; 8. Ll., 23990; 7. Bessel, 922; 7·5."—*B.'s. obs.:* no marked colour; several obs.; 7–7·5.—*Addit. obs.:* 1879, April 2, 7·5; orange: April 17, 7·5; pale orange; *s. p.* of 2. 1879, May 2, seems slightly more yellow than the f. one (D.). 1880, March 8, 6; faint red (Do.), 1885, April 29, 7·0; pale red; 7·0; blue closely f.: May 12, 7·0; pale orange; 8·0; yellow. The mag. in the D. M. for the p. star is 6·3, and the f. 7·2. There seems a possibility of *var.* here (Es.).
370	"	"h. 3435; central and largest star red. South of this is a 13 mag., also red." A. G. C., 7½; red. Thome (private letter), red 7½; another red 5^{s}·9 f., 1′ n., 8½. Stone, red.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
371	296	155*a*	. . . .	XII.^{h} 47^{m} 26^{s}	+ 3^{s}·53	– 59° 46′·4	– 0′·33	9·0
372	—	—	D. M. – 10°. 3570,	48 35	3·14	– 11 3·1	0·33	6·0
373	—	—	D. M. – 9°. 3584,	49 8	3·12	– 9 50·0	0·33	8·3
374	298	155*b*	. . . .	52 6	2·38	+ 66 35·4	0·32	7·3
375	299	156	. . . .	52 40	2·97	+ 18 21·8	0·32	8·1
376	—	—	D. M. – 2°. 3638,	XIII. 4 3	3·09	– 2 47·9	0·32	8·3
377	—	—	A. G. C., 18055, .	10 44	3·89	– 63 59·6	0·32	8·0
378	—	—	D. M. + 47°. 2053,	18 23	2·58	+ 47 34·5	0·32	7·0
379	—	—	D. M. – 13°. 3699,	18 31	3·18	– 13 31·7	0·31	8·7
380	305	158*a*	W Virginis, . .	20 21	3·09	– 2 48·4	0·31	var.
381	307	159*a*	V. Virginis, . .	22 7	3·09	– 2 36·1	0·31	var.
382	308	160	R Hydræ, . . .	23 42	3·27	– 22 42·7	0·31	var.
383	310	161	S Virginis, . . .	27 25	3·51	– 6 37·8	0·31	var.
384	—	—	D. M. – 3°. 3515,	36 3	3·10	– 3 28·0	0·30	8·7
385	312	—	83 Ursæ, . . .	36 35	2·29	+ 55 13·4	0·30	var.
386	—	—	B. 4629, ...	41 34	4·13	– 61 33·2	0·30	7½
387	—	—	D. M. – 3°. 3535,	42 42	3·11	– 4 9·1	0·30	8·0
388	313	—	L. 5686, . . .	42 49	3·37	– 27 49·0	0·30	7·0
389	—	—	D. M. + 38°. 2501,	55 41	2·56	+ 38 24·8	0·29	8·9
390	—	—	L. 5794, . . .	58 58	4·37	– 62 55·1	0·29	7·4
391	317	164	. . . .	59 12	3·07	+ 0 4·2	0·29	8·8
392	—	—	L. 5814, ...	XIV. 0 24	3·97	– 53 10·0	0·29	7½
393	—	—	D. M. – 13°. 3824,	0 45	3·23	– 13 40·7	0·29	7·0
394	—	—	. . . .	1 3	2·99	+ 6 34·0	0·29	neb.
395	319	165	. . . .	1 19	4·20	– 59 12·0	0·29	9

No.	OBSERVATIONS.	
371	*Schj.'s notes*, .	" Cape obs., p. 17, star No. 63; red."—*Addit. obs.:* Pechüle; 1883, Jan. 6, rouge. Probably Thome's second star.
372	Konkoly, . .	1885, May 12, gelblich roth; 7. A. G. C., 6·1.
373	Konkoly, . .	1885, May 12, gelblich roth; 5·5. Weisse; 9.
374	*Schj.'s notes*, .	" D'Arrest; auffällig röthlich."—*Addit. obs.:* 1879, April 16, 7·5; orange: April 24, 7·2; orange. 1880, April 30, 7·5: May 4, 7·5; deep orange (D.). 1880, Feb. 14, 6·5; red (Do.). 1885, Aug. 20, 7; orange red: 1886, Aug. 1, 7·0; red, with orange hue (Gemmill).
375	,,	" D'Arrest; rubra; 8. Ll., 24148; 8."—*B.'s obs.:* several in several years, always exceedingly pale red; 8–8·5.—*Dublin obs.:* Copeland; 1876, March 22, full orange.—*Addit. obs:* 1879, March 19, no colour: March 31, 8·0; orange: April 4, 8·2; orange (D.). 1881, May 14, reddish, not red (H.). 1885, March 9, 8·0; red orange (Es.).
376	Konkoly, . .	1884, May 14, 8; röthlich gelb.—*E.'s obs.:* 1888, April 14, 17, 8·0; orange.
377	Holden, . .	1883, 7·7; brick red.
378	Dunér, . . .	Rouge-jaune.
379	Konkoly, . .	1884, May 21, 7·5; gelblich roth. Ll., 8·5.
380	*Schj.'s notes*, .	" Schönf., A. N., 1586; röthlich." See Gore's Var. Star Catalogue.
381	,,	" Schönf. Cat.; stark gelbroth." See Gore's Var. Star Catalogue.
382	,,	" Piazzi; rubei coloris. Schmidt; A. N., 1902; very deep red." See Gore's Var. Star Catalogue.
383	,,	" Pogson (Radcl. xv., 288); vivid red. Auwers, A. N., 1238; orange." See Gore's Var. Star Catalogue.
384	Konkoly, . .	1884, May 20, gelblich roth; 8.—*E.'s obs.:* 1888, April 14, 8·0; pale orange red.
385	Birmingham, .	Fine orange. This star, which is ordinarily of the 6 mag., I saw as large as δ Ursæ, between 3 and 4 mag., on Aug. 6, 1868. It was smaller on the next night, and slowly diminished to its usual magnitude. See Ast. Register, Nov. 1868.—*Addit. obs.:* 1880, Feb. 20, 5.5; red (Do.). Es., several obs.; always orange. Fr., orange. See Gore's Var. Star Catalogue.
386	Russel, . .	(Private letter); 8; red.
387	Konkoly, . .	1884, May 20, 7; gelblich roth. Weisse, 9.
388	Burnham, . .	M. N., xxxvi., No. 7; deep red, or crimson, with distant bluish companion, 7 mag.—*Addit. obs.:* Thome (private letter); very red. Pickering; very red. Pechüle; rouge. *E.'s obs.:* 1887, April 27, very red.
389	Dunér, . . .	Rouge-jaune.
390	Russel, . .	(Private letter); 8; red. h. 4642.
391	*Schj.'s notes*, .	" Bond; reddish; 8."—*Addit. obs.:* 1879, March 19, 8·7; pale orange: March 31, 8·5; orange: April 17, 8·5; pale red (D.). 1881, May 14, yellowish (H.). 1885, May 1, 8; only yellow (Es.).
392	Russel, . .	(Private letter); 8; orange red. (Russel calls this h. 4646, but the place of that star, assuming it to be identical with A. G. C., 19137, is xiv.^{h} 0^{m} 33^{s}–47° 48′·3.)
393	Konkoly, . .	1884, May 20, gelblich roth; 7.
394	Rosse, . . .	Note on G. C., 3785. 1861, March 17. A neat double star 10, white; 12, dusky red, with a nebula *n.* of it. [Σ 1801.]
395	*Schj.'s notes*, .	" Cape obs.: double. Both stars brick red." Russel (private letter); h. 4649 . 9, 9, both red. A. G. C., orange yellow.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
396	—	—	D. M. - 2°. 3804, .	xiv.^{h} 7^{m} 4^{s}	+ 3^{s}·104	- 2° 47′·5	- 0′·29	7·8
397	—	—	D. M. - 13°. 3845,	7 13	3·24	- 13 20·3	0·29	7·0
398	323	166	R Centauri, . .	8 39	4·26	- 59 24·0	0·29	var.
399	325	167*a*	. . . .	10 1	1·10	+ 69 56·9	0·28	5·3
400	327	168	. . . .	18 54	2·96	+ 8 35·2	0·27	7·3
401	—	—	D. M. + 22°. 2695,	19 12	2·76	+ 21 58·0	0·27	8·2
402	328	169	. . . .	19 15	2·70	+ 26 12·3	0·27	8·0
403	—	—	D. M. - 12°. 4042,	19 20	3·24	- 12 51·3	0·27	6·7
404	329	170	. . . .	23 55	3·15	- 5 29·5	0·27	neb.
405	—	—	V Bootis, . . .	25 18	2·42	+ 39 21·0	0·27	var.
406	331	173*a*	R Cameli, . . .	25 53	- 4.94	+ 84 19·8	0·27	var.
407	—	—	D. M. - 6°. 4025, .	27 32	+ 3.16	- 6 27·0	0·27	7·8
408	333	172	. . . .	28 49	3·82	- 42 53·1	0·27	8½
409	334	173	. . . .	30 8	2·45	+ 37 6·6	0·26	6·2

No.	OBSERVATIONS.	
396	Konkoly, . .	1884, May 22, gelblich roth; 7·5. A. G. C., 8.
397	Konkoly, . .	1884, May 20, gelblich roth; 7·5.
398	*Schj.'s notes*, .	"Cape obs.: ruby, or high orange." Argentine zone obs., red. See Gore's Var. Star Catalogue. Thome (private letter); red.
399	"	"D'Arrest; 1874, August, stark gelbroth."—*B.'s obs.:* 1876, March 22, faint orange; 6.—*Addit. obs.:* 1879, March 31, 5·0; yellow (D.). 1880, Feb. 14, red (Do.).
400	"	"D'Arrest; fulva, et quidem egregie; 6. Ll., 26325; 6. Bessel, 310; 7. Birmingham (M. N., XXXIV.), bemerkte nicht immer die rothe farbe."—*B.'s obs.:* 1872, April, no tinge of red; 6: May 9, a tinge of very palest orange. 1873, March 14, perhaps slightly yellow: April 20, light straw colour; 6·5: April 23, no certain colour. 1874, April 10, perhaps faint straw colour; 7: May 7, perhaps reddish: 6: June 7, reddish; 6–6·5. 1875, May 15, no colour. 1876, March 31, perhaps light straw colour; 7: April 13, pale orange; 7·5; April 30, May 19, perhaps slightly yellowish; 6·5–7; seems strikingly *var.* in colour.—*Webb's obs.:* 1872, May 8, pale orange; 7.—*Addit. obs.:* 1879, March 31; 7·7; orange: April 2, 7·2; yellow: May 2, pale yellow: May 3, no colour (D.). 1881, May 11, yellowish red: May 14, fine yellow (H.). 1881, April 25, yellow. 1885, May 1, very pale red. My obs., 1881–1885, show this star $\frac{3}{10}$ below the bluish star 10′ N. See Gore's Suspected Var. Stars (Es.).
401	Lindemann, .	No. I., 25. 1876, Sept. 9, röthlich. 1877, April 22, roth. 1878, April 9, roth.—*E.'s obs.:* 1887, April 28, 8·3; pale red.
402	*Schj.'s notes*, .	"Cape obs.: vivid red; 7·5. Ll., 26342; 7·5. Einmal von Birmingham von 9ter Grosse beobachtet."—*B.'s obs.:* 1872, April 27, fine orange red; 7·3. 1874, April 10, fine red; 9: May 23, fine red; 8: June 27, good red; 7·5. 1876, March 31, red, not deep; 8: April 13, red, not deep; 8·5: April 30, pale red; 7·5. *Variable* (?)—*Webb's obs.:* 1872, May 8, genuine, though not very deep ruby.—*Addit. obs.:* 1879, April 16, 8·0; fine red; May 1, 8·0; red: May 14, decidedly red (D.). 1880, April 8, 7·5; intensely red (Do.). 1881, May 11, 8; full red: May 15, fine red (H.). 1885, April 19, 7·5; orange red (Fr.). 1885, May 1, 8½; very fine red: May 12, 8·3. 1886, April 12, 7·0 very red: May 6, 7·8; very red (an 8·3 f. 40^s ±). 1887, Feb. 25, 7·8; very red. This star is evidently variable (Es.).
403	Konkoly, . .	1884, May 20, gelblich roth; 7·5. A. G. C., 6·7.
404	*Schj.'s notes*, .	"Schönf. (Neb. Cat., p. 66 und 68); röthlich. D'Arrest (Sid. Neb., p. 310); rubicunda, et quidem manifesto; 8. Schj., 5142; 8·5."—*B.'s obs.:* 1873, March 19, pale reddish, in a very remarkable nebula; 8·5. 1874, April 10, not red; 8·5: May 9, very pale red; 8. 1876, April, faintly reddish; 8.—*Addit. obs.:* Earl of Rosse; 1871, Feb. 25, one star, near nebula, and *s. f.*, is red; 8–8·5. 1879, May 11, 8·0; yellow. 1880, April 30, 8·5; deep orange: May 13, 8·2; yellow (D.). 1881, May 11, 15; a little reddish (H.). 1878, April 2, faint red; 9·0. 1885, May 1, 8·0; yellowish. 1888, April 17, 7·5; pale orange red; *var.*? (Es.).
405	Dunér, . .	Rouge-jaune. Le 21 Mai 1884 l'étoile n'était que de la grandeur 9·5, tandis que sa grandeur fut évaluée 7·0 le 29 Avril et le 9 Mai 1880. The star is D. M. + 39° 2773.
406	*Schj.'s notes*, .	"Schönf. Cat.; röthlich." See Gore's Var. Star Catalogue.
407	Arg. Gen. Cat.,	No. 19717. Crimson.—*E.'s obs.:* 1888, April 17, 8·0; pale orange red.
408	*Schj.'s notes*, .	"Cape obs.: ruby-coloured, 9."—*Addit. obs.:* Pechüle; 1883, Jan. 6, 9·0; red. A. G. C., orange.
409	"	"Hist. Cél., p. 164; rouge; 6. Secchi; rossa pallida. Birmingham (M. N., XXXIV.); giebt ihm *straw colour*. D'Arrest; gelbroth; 7."—*B.'s obs.:* 1872, April 27, 1874, April 10; May 9, faint straw colour; 7: June 7, faint straw colour; 6·5. 1875, May 15, faint straw colour. 1876, March 31, perhaps pale straw colour; 6·5: April 13, faint orange; 6·5: April 30, faint yellow; 6.—*Webb's obs.:* 1872, May 24, pale yellow.—*Addit. obs.:* 1879, April 17, May 14, no colour. 1880, May 6, yellow or no colour (D.). 1880, April 8, 6; pale ruddy (Do.). 1885, May, 6·8; very pale red (Es.).

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
410	336	173*c*	R Bootis, . . .	xiv.^{h} 32^m 20^s	+ 2^s·65	+ 27° 12′·8	− 0′·26	var.
411	—	—	D. M. + 33°. 2482,	34 39	2·53	+ 33 0·5	0·26	8·2
412	—	—	D. M. − 14°. 4006?	34 51	3·29	− 14 50·8	0·26	8·2
413	—	—	D. M. − 11°. 3789,	36 4	3·24	− 11 45·9	0·26	7·0
414	—	—	D. M. + 32°. 2504,	36 35	2·55	+ 32 1·5	0·26	8·0
415	338	—	54 Hydræ, . . .	39 38	3·47	− 24 58·6	0·26	5¼
416	—	—	D. M. + 15°. 2758,	40 34	2·83	+ 15 35·6	0·26	5·5
417	—	—	A. G. C., 20053, .	41 56	4·03	− 48 10·8	0·25	9·0
418	—	—	. . . .	44 ::	::	− 69 57 ::	0·25	—
419	—	—	D. M − 11°. 3841,	51 46	3·27	− 11 59·9	0·24	7·0
420	342	—	D. M. + 66°. 878,	55 50	0·95	+ 66 22·2	0·24	4·5
421	—	—	L. 6250, . . .	xv. 3 26	3·49	− 23 33·9	0·23	6·8
422	345	174	L. 6222, . . .	3 46	5·67	− 69 39·8	0·23	6·2
423	—	—	D. M. − 15°. 4048,	6 11	3·35	− 15 59·9	0·23	7·2
424	—	—	D. M. + 66°. 890,	6 42	0·85	+ 66 22·2	0·23	6·5
425	—	—	D. M. + 19°. 2935,	7 4	2·73	+ 19 23·4	0·23	5·9
426	—	—	. . . .	8 ::	::	− 56 27 ::	0·23	10·0
427	—	—	ϕ' Lupi, . . .	14 49	3·79	− 35 51·7	0·22	3·6
428	347	176	. . . .	14 58	6·97	− 75 32·3	0·22	8¾
429	348	176*a*	S Libræ, . . .	15 5	3·44	− 19 59·4	0·22	var.
430	—	—	. . . .	16 10	3·63	− 28 47·2	0·22	—
431	349	177	S Serpentis, . .	16 30	2·81	+ 14 42·6	0·22	var.
432	350	177*a*	S Coronæ, . . .	16 55	2·42	+ 31 45·8	0·22	var.
433	—	—	L. 6427, ...	28 40	4·08	− 44 1·6	0·21	6·2
434	354	—	α Coronæ, . . .	30 2	2·54	+ 27 5·1	0·20	—
435	356	178	τ^4 Serpentis, . .	31 22	2·78	+ 15 27·9	0·20	6·7

No.	OBSERVATIONS.	
410	*Schj.'s notes*, . .	"Schönf. Cat.; roth." See Gore's Var. Star Catalogue.
411	Espin, . . .	203; 1886, April 12, 8·3; very red. 1887, Feb. 26, 8·4; fine red: April 28, 8.0; very red. 1888, April 11, 8·0; red.
412	Holden, . .	25. 1881, May 29, 8; red.—*E.'s obs.:* 1887, April 23, 8·5; yellow.
413	Konkoly, . .	1884, May 24, gelblich roth; 8. A. G. C., 7.
414	Espin, . . .	204. 1886, April 12, 8·5; red: April 26, 8·3; orange red. 1887, Feb. 26, 7·5; fine red: April 28, 8·0; pale red. 1888, April 11, 7·6; red. *Var.* ?
415	South & Hersc.,	Double; 5·5; 7·5; red; blue.—*Addit. obs.:* Smyth; 1831, pale orange, violet. 1851, deep yellow, reddish violet. Webb; 1854, April 17, pale yellow, ruddy purple. Pechüle remarks, 1883, Jan. 6: La grande bleue, et l'autre rouge H. and S. the other way. 1888, April 17, no particular colour in either (Es.).
416	Dunér, . .	Rouge-jaune. Vogel; röthlich gelb. D'Arrest; hellgelb.
417	Russel, . .	(Private letter); double; 8; red.
418	Russel, . .	(Private letter); 7; red.
419	Holden, . .	26. 1881, May 29, strong reddish yellow; 7·8 mag.—*E.'s obs.:* 1887, April 23, 8·0; red: May 13, 7·5; red.
420	Secchi, . .	*Prodromo*, &c.; 1876, No. 261, gialla; 5. Birmingham; 1876, Oct. 6, deep red orange; 4.—*Addit. obs.:* 1880, Feb. 14, yellow. Franks; splendid orange. Chambers; orange. Dunér; rouge-jaune. H. P., 4·8.
421	Holden, . .	29. 1881, May 22, 7·5; red.—*E.'s obs.:* 1887, April 27, 7·0; orange.
422	*Schj.'s notes*, .	"Cape obs.: almost scarlet." A. G. C., red, *var.* ? Stone; Cape Cat.; red.
423	Konkoly, . .	1885, May 10, 7; gelblich roth.
424	Dunér, . . .	Rouge-jaune.
425	Dunér, . . .	Rouge-jaune. Vogel; gelb.
426	Russel, . .	(Private letter). In same field as Russel; No. 108; 2nd Cat.; double points to it.
427	Thome, . .	(Private letter); very red.
428	*Schj.'s notes*, .	"Cape obs.: very high red, 7·0." A. G. C., red.
429	,,	"Schönf. Cat.; röthlich." See Gore's Var. Star Catalogue.
430	Holden, . .	30. 1881, May 22, 8·5; red.
431	*Schj.'s notes*, .	"Schönf. Cat.; sehr roth." See Gore's Var. Star Catalogue.
432	,,	"Schönf. Cat.; rothgelb." Schm.; red. See Gore's Var. Star Catalogue.
433	Thome, . .	(Private letter); very red.
434	Smyth, . .	In field with α Coronæ, and nearly midway between it and a little double, is a red star 10. The double precedes α 48^{s}·3; position, 275°. The place given is that of α.—*Addit. obs.:* Webb; 1850, July 30, only a glimpse object.—*E.'s obs.:* 1885, June 9, 11 mag.; July 5, below 11·0 mag.; July 13, 12 mag. 1886, March 9, 12·0.
435	*Schj.'s notes*, .	"D'Arrest; dunkel roth; 7·5. Ll., 28448; 6. Bessel, 675; 7. Secchi; rossa viva; 6."—*B.'s obs.:* 1872, April 7, not seen: May 11, pale orange; 7·2. 1873, April 21, reddish; 7·3.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
435	356	178	τ^4 Serpentis, . .	xv.^{h} 31^m 22^s	+ 2^s·78	+ 15° 27′·9	- 0′·20	6·7
436	—	—	ψ Lupi, ...	32 47	3·79	- 34 3·1	0·20	5·1
437	—	—	. . . .	37 53	3·09	- 1 20·9	0·20	—
438	359	179	R Coronæ, . . .	44 2	2·47	+ 28 29·7	0·19	var.
439	361	182	V Coronæ, . . .	45 35	2·14	+ 39 54·2	0·19	var.
440	360	181	R Serpentis, . .	45 37	2·76	+ 15 28·1	0·19	var.
441	364	182*a*	R Libræ, . . .	47 22	3·39	- 15 54·5	0·18	var.
442	362	180	. . . .	47 48	7·02	- 74 9·7	0·18	9½
443	—	—	D. M. - 20°. 4355,	48 23	3·49	- 20 29·4	0·18	8·3
444	—	—	D. M. - 20°. 4362,	49 56	3·48	- 20 27·5	0·18	8·2
445	—	—	D. M. - 15°. 4221,	50 51	3·39	- 15 42·8	0·18	6·8
446	366	183	D. M. + 36°. 2672,	54 25	2·23	+ 36 25·4	0·17	8·8
447	368	184	R Herculis, . .	xvi. 1 16	2·68	+ 18 40·1	0·15	var.
448	369	185	. . . .	2 36	2·59	+ 22 7·1	0·16	6·5
449	372	186	. . . .	4 5	3·05	+ 1 6·6	0·16	7·0
450	—	—	. . . .	4 : :	: :	- 53 58 : :	0·16	—
451	—	—	L. 6713, . . .	4 43	4·64	- 53 23·1	0·16	6·5
452	—	—	κ Normæ, . . .	4 48	4·69	- 54 20·7	0·16	5·5
453	374	187	. . . .	10 6	4·27	- 45 31·8	0·15	8½

No.		OBSERVATIONS.
435	*continued*—	1874, April 10, pale red, 7 : May 8, reddish; 7·5 : June 7, pale red; 6–6·5. 1875, May 15, reddish, 6·5–7. 1876, March 31, pale orange red; 8 : April 13, pale orange; 7 : May 19, faintly reddish; 7. *Variable* (?)—*Dublin obs.* : Ball; 1876, Aug. 11, very red—*Addit. obs.* : 1879, April 16, 17; 6·5 : May 15; reddish (D.). 1885, June 9, fine pale red, just equal star 10′ s. (7·0 ; D. M.), which is blue. 1886, April 29, 7·0 ; very orange red (Es.)
436	Thome, . .	(Private letter); very red.
437	Holden, . .	127. 1882·43 ; 10·3 ; deep red : 1882·44 ; 10 ; red.—*E.'s obs.* : 1887, May 9, 9·6 ; looks red.
438	*Schj.'s notes*, .	" Auwers, A. N., 1238 ; röthlich." See Gore's Var. Star Catalogue.
439	,,	" Cape obs.: fine ruby ; 9·5." This star, which was not seen by Birmingham, 1873, March 14, 19, April 20 : 1874, April 10 ; nor by Ball, 1876, Aug. 1, was found to be variable by Dunér, A. N., 2227.—*E.'s obs.* : very red, 1885, Jan. 9. See Gore's Var. Star Catalogue.
440	,,	" Winnecke, A. N., 1224 ; ausserordentlich roth. Auwers, A. N., 1238 ; nicht stark roth. Schönf. Cat. ; roth gelb. Vogel, A. N., 2000 ; gelbroth." —*B.'s obs.*: 1872, April 27, slight red tinge. 1876, April 13, pale red. See Gore's Var. Star Catalogue.
441	,,	" Schönf. Cat. ; röthlich." See Gore's Var. Star Catalogue.
442	,,	" Cape obs. : sombre red ; 9." A. G. C., orange yellow.
443	Holden, . .	128 ; 1882·43 ; 8–9 ; orange red : 1882·49, 7·8 ; orange red.—*E.'s obs.* : 1888, April 17, 8·3 ; red.
444	Holden, . .	129 ; 1882·43, 8 mag. ; orange red.—*E.'s obs.* : 1889, April 17, 8·1 ; pale red.
445	Konkoly, . .	1885, June 8, 7 ; gelblich roth. A. G. C., 7½.
446	*Schj.'s notes*, .	" Cape obs. : ruby red ; 10. Not seen by Schönf., A. N., 1977."—*B.'s obs.* : not seen in several trials in 1873 and 1874.—*Webb's obs.* : 1871, Aug. 12, and 1873, Sept. 24, not seen.—*Addit. obs.* : 1879, April 25, 10·0 ; seems red (D.). D. gives a second star, 48^{s}·3 f. 3′·1 s., 9·6 ; orange. Neither of these stars agree with H.'s place: there can be little doubt that D. M. + 36°. 2672, is really the star. My obs. are, 1887, March 27, 9·0 ; red : same, April 14 (Es.).
447	,,	" Schönf., A. N., 1064 ; roth. Auwers, A. N., 1238 ; roth." See Gore's Var. Star Catalogue.
448	,,	" D'Arrest ; rubrosubflava ; 7·5. Ll., 29410 ; 6. Bessel, 1569, '70, '71 ; 7. Secchi, rossina." —*B.'s obs.* : 1872, April 27, not red, nor yellow. 1873, March 14, 19, April 20, yellow ; 7 ; with small distant *comes*, 40°–45° est. 1874, April, May 8, pale yellow ; 7–7·5 : May 23, yellowish ; 6·5. 1875, May 15, yellowish, 7 : July 25, 27, yellowish ; 7. 1876, March 22, pale yellowish, 7·5 : April 13, yellowish, 7·5.—*Webb's obs.* : 1873, Sept 27, very pale red ; 8·5. A *comes* 11 mag., n. f.—*Addit. obs.* : 1880, May 8, 7·0 ; orange : June 9, 6·5 ; deep orange (D.). 1881, May 14, not red, straw colour (H.).
449	,,	" D'Arrest ; subrubra ; 8. Ll., 29441 ; 7. Bessel, 24 ; 7. Stets von Birmingham (M. N., xxxiv.), als *reddish* aufgeführt."—*B.'s obs.* : frequently observed in several years, and always reddish, from 7 to 8 mag., until May 15, 1874, when it appeared pale yellow, and 6–6·5 mag. 1875, July 25, no colour ; 7. 1876, April 1, no colour ; 7·5 : April 13, if any colour, yellowish ; 7·5. *Variable* (?).—*Addit. obs.* : 1879, June 10, pale orange, if any colour. 1880, April 30, 7·5 ; no colour : June 4, 7·0 ; yellow : June 10, deep orange (D.). 1881, May 14, not red, lemon yellow (H.).
450	Russel, . .	(Private letter) ; h. 4835 ; 9, 9 ; both red.
451	Thome, . .	(Private letter) ; very red.
452	Thome, . .	(Private letter) ; very red.
453	*Schj.'s notes*, .	" Cape obs. : ruby red ; 8·5."—*Addit. obs.* : A. G. C., orange red.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
454	—	—	W Ophiuchi, . .	xvi.^{h} 15^{m} 29^{s}	+ 3^{s}·23	− 7° 26′·2	− 0′·15	var.
455	—	—	. . . .	14 59	3·88	− 34 1·5	0·15	—
456	378	188	. . . .	18 46	3·07	+ 0 3·5	0·14	8·8
457	379	189	V Ophiuchi, . .	20 36	3·33	− 12 10·6	0·14	var.
458	380	190	U Herculis, . .	20 56	2·65	+ 19 8·6	0·14	var.
459	—	—	D. M. − 7°. 4292, .	21 48	3·23	− 7 20·6	0·14	6·2
460	—	—	. . . .	24 11	3·09	− 0 53·9	0·13	—
461	382	191*a*	30 Herculis, . .	25 2	1·96	+ 42 7·4	0·13	var.
462	384	—	H Scorpii, . . .	29 8	3·93	− 35 1·7	0·13	4·4
463	—	—	W Herculis, . .	31 18	2·12	+ 37 33·7	0·13	var.
464	—	—	R Ursæ Minoris, .	31 28	− 0·86	+ 72 30·8	0·13	var.
465	—	—	D. M. − 12°. 4563,	33 3	+ 3·34	− 12 6·2	0·12	8·0
466	385	192	. . . .	33 34	3·85	− 32 9·8	0·12	9
467	—	—	D. M. + 49°. 2530,	35 32	1·63	+ 49 4·8	0·12	7·3
468	—	—	42 Herculis, . .	35 45	1·63	+ 49 8·6	0·12	5·0
469	386	—	D. M. + 36°. 2772,	39 12	2·14	+ 36 43·4	0·12	7·7
470	388	193	. . . .	43 43	3·07	+ 0 6·9	0·11	8·4
471	389	—	D. M. + 42°. 2749,	43 49	1·92	+ 42 26·8	0·11	6·5
472	—	—	D. M. − 0°. 3195, .	45 24	3·08	− 0 16·5	0·11	—
473	391	194	. . . .	45 33	3·20	− 5 59·3	0·11	8·8
474	392	195	S Herculis, . . .	46 53	2·73	+ 15 7·6	0·10	var.
475	393	195*a*	L. 7038, . . .	48 4	4·11	− 39 19·5	0·10	7·0
476	394	196	. . . .	50 31	3·04	+ 1 35·8	0·10	8·0
477	—	—	A. G. C., 22956, .	51 8	3·91	− 33 26·2	0·10	7½
478	397	197*a*	Nova, 1848, . .	53 21	3·36	− 12 43·5	0·10	var.

No.	OBSERVATIONS.	
454	Schönfeld, .	(Viertel Ast. Ges., xv., p. 82), very red. See Gore's Var. Star Catalogue.
455	Holden, . .	No. 39. 1881, June 2, 9 ; red.
456	*Schj.'s notes*, .	" Bond, I., p. 303 ; garnet red ; 10. Bessel, 314 ; 8·5. Schj., 5791 ; 8·5."—*Addit. obs.:* 1879, May 14, 8·2 ; yellow. 1880, June 4, 8·8 ; orange : June 10, 8·5 ; orange (D.).
457	„	" Cape obs. : dull brick red ; 8. Birmingham (M. N., xxxiv.) ; 1873, April 6, good red ; 9–9·5. 1874, April 10, genuine ruby ; 9 : May 8, fine red ; 7·5."—*B.'s addit. obs.:* 1875, May 15, red, not deep ; moonlight ; 8·5 : May 26, red, not deep ; no moon ; 8·5. 1876, April 13, good red ; 9. *Variable* (?).—*Addit obs :* 1879, June 2, 8·2 ; reddish : June 10, 8·0 ; deep orange : June 9, 8·2 ; red (D.). See Gore's Var. Star Catalogue.
458	„	"Schönf., A. N., 1523 ; roth. Vogel, A. N., 2000 ; roth." See Gore's Var. Star Catalogue.
459	Dunér, . .	Rouge-jaune. D'Arrest ; 6 mag. ; gelblich. Konkoly ; gelb. Franks ; fine orange. Espin, 1878, April 2, 5·7 ; fine red. Schönfeld ; roth.
460	Konkoly, . .	No. 1335. 1886, July 2, gelblich roth ; 8 mag.
461	*Schj.'s notes*, .	" Schönf. Cat. ; rothgelb." Schmidt, A. N., 1902 ; very deep red.—*B.'s obs.:* red orange. See Gore's Var. Star Catalogue.
462	Schmidt, . .	(A. N., 1902) ; red. A. G. C., red.
463	Dunér, . . .	Rouge-jaune.
464	Pickering, .	Red and Variable.
465	Holden, . .	No. 40. 1881, May 21, 8 ; red.
466	*Schj.'s notes*, .	" Cape obs. : deep red, like a drop of blood ; 8·0." A. G. C., red.
467	Dunér, . .	Rouge-jaune. D'Arrest ; 7·8 ; gelblich.
468	Dunér, . .	Rouge-jaune. D'Arrest ; sehr gelb. Franks ; pale orange.
469	D'Arrest, . .	(A. N., 2009) ; colour not given ; mag. 8·3. Birmingham ; 1876, August, pale red ; 8·5. Dunér ; jaune-rouge.
470	*Schj.'s notes*, .	" Bond, I., p. 293 ; reddish ; 9. Ll., 30593 ; 8. Bessel ; 803 ; 8."—*Addit. obs.:* 1879, June 2, 8·3 ; no colour. 1880, May 8, 8·5 ; deep orange : June 9, 8·3 ; orange (D.).
471	D'Arrest, . .	Hellbraun. Dunér ; jaune-rouge. Franks ; pale orange.
472 .	Holden, . .	No. 41. 1881, May 22, dull red ; 8 mag.
473	*Schj.'s notes*, .	" Schj., 5990 ; roth."—*B.'s obs.:* 1872, May 9, not seen. 1873, April 6 and 20, not red ; 9·5 : April 23, pale reddish ; 9–9·5. 1874, April 10, perhaps reddish ; 10–11 ; May 9, reddish ; 10 at most. 1875, May 15, no colour in strong moonlight ; 11 : July 25, perhaps reddish ; 10. 1876, April 13, and May 19, no colour ; 10. *Variable?—Addit. obs.:* 1879, June 19, 8·2 ; reddish. 1880, May 6, 8·8 ; orange : June 4, 8·8 ; orange : June 14, 8·7 ; orange (D.). 1886, May 14, 9·5 ; yellow (Es.).
474	„	"Schönf., A. N., 1064 ; roth. Auwers, A. N., 1238 ; roth. Vogel, A. N., 2000 ; orangeroth" See Gore's Var. Star Catalogue.
475	„	"h. 3654 ; red ; 9."—*Addit. obs.:* A. G. C., red.
476	„	" Schj., 6029 ; roth ; 8·5. Ll., 30790 ; 8. Bessel, 925 ; 8."—*Addit. obs.:* 1875, July 17, 8·0 ; reddish (C.). 1879, May 14, 8·0 ; no distinct colour (D.). 1886, May 14, 8·5 ; very pale orange red. 1887, March 27, 7·8 ; orange (Es.).
477	A. G. C., . .	Crimson.
478	*Schj.'s notes*, .	" Hind's Nova in Ophiuchus ; grellroth." See Gore's Var. Star Catalogue.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
479	396	197	. . . .	XVI.^{h} 53^{m} 33^{s}	+ 4^{s}·89	− 54° 54′·4	− 0″·10	8½
480	398	198	. . . .	54 1	3·16	− 4 3·3	0·09	7·3
481	401	198*a*	R Ophiuchi, . .	XVII. 1 27	3·44	− 15 56·7	0·08	var.
482	—	—	L. 7152, ...	4 56	5·05	− 56 45·3	0·07	7·0
483	—	—	. . . .	10 46	3·43	− 15 30·7	0·07	—
484	405	199*a*	68 Herculis, . .	13 6	2·21	+ 33 13·1	0·07	var.
485	406	—	D. M. + 31°. 2994,	13 27	2·27	+ 31 33·5	0·07	8·5
486	407	—	D. M. + 2°. 3296,	14 13	3·02	+ 2 16·4	0·07	7·0
487	—	—	. . . .	15 ::	::	− 56 8::	0·06	—
488	408	200	43 Ophiuchi, . .	16 26	3·77	− 28 2·1	0·06	5·8
489	—	—	D. M. − 21°. 4607,	20 7	3·58	− 21 22·3	0·06	7·5
490	—	—	D. M. + 17°. 3241,	21 1	2·69	+ 17 1·0	0·06	6·2
491	409	201	. . . .	22 51	4·01	− 35 33·3	0·05	9½
492	410	202	. . . .	23 14	3·53	− 19 23·0	0·05	7·8
493	—	—	. . . .	24 12	3·97	− 33 58·5	0·05	—
494	—	—	D. M. + 71°. 841,	25 1	− 0·99	+ 71 58·0	0·05	6·8
495	—	—	D. M. + 14°. 3279,	28 44	+ 2·72	+ 14 55·3	0·05	6·2
496	—	—	. . . .	28 52	3·94	− 33 25·4	0·05	—
497	413	—	D. M. + 12°. 3248,	28 55	2·78	+ 12 36·3	0·05	8·2
498	414	203	. . . .	32 42	4·25	− 41 34·1	0·04	7¾
499	415	204	. . . .	33 49	5·17	− 57 40·0	0·04	7·0
500	416	—	D. M. + 31° 3075,	35 47	2·27	+ 31 15·8	0·04	6·5
501	418	205	. . . .	38 29	+ 3·52	− 18 36·5	0·03	8·5

No.	OBSERVATIONS.	
479	***Schj.'s notes,*** .	" Cape obs.; intense ruby red; 9 (double)."—*Addit. obs.:* Russel; 11, or 11½; ruby red.
480	"	" Schj., 6046; gelbroth; 8. Birmingham (M. N., xxxiv.), findet ihn stets *schwach röthlich* und 9·5 oder 9."—*B.'s addit. obs.:* 1875, May 15, reddish; 8. 1876, April 13, may have a reddish tinge; 9.—*Addit. obs.:* 1875, July 6, 8·0; yellow (C.). 1879, May 15, 7·9; yellow: June 10, 9·5; sky very misty: June 19, 8·0; reddish (D.). 1878, April 4, 9·0, good red. 1886, May 14, 8·5; pale orange red. *Variable?* (Es.).
481	"	" Schönf. Cat.; schwach roth." See Gore's Var. Star Catalogue.
482	Holden, . .	No. 133. 1883; 7·0; red.
483	Konkoly, . .	1886, June 21, gelblich roth; 7·5. Konkoly identifies it with Ll. 31367, and notes that Ll. calls it 3 mag. There is no star in the D. M. in Dr. Konkoly's place.
484	***Schj.'s notes,*** .	" Schönf. Cat.; roth." See Gore's Var. Star Catalogue.
485	Burton, . .	(Private letter); red; 8.
486	D'Arrest, . .	A. N., 2044; hellröthlich; 7·8.—*Addit. obs.:* 1881, May 14; 7; red (H.).
487	Russel, . .	(Private letter); 10 mag.; red.
488	***Schj.'s notes,*** .	" Argel., 16692; röthlich. Secchi; colore di rosa."
489	A. G. C., . .	Crimson; 7½.—*E.'s obs.:* 1888, May 4, 7·0; pale orange red.
490	Vogel, . . .	(Spec. Beob.); 1881, July 22, gelblich roth.—*E.'s obs.:* 1836, June 4, 7·0; pale orange red.
491	***Schj.'s notes,*** .	" Cape obs.: very deep red; 9."
492	"	" Cape obs.: a ruby star; 8·5. Argel., 16844, '45, '46; 8·8, und 7."—*B.'s obs.:* 1873, May 18, fine full red; 8, at least. 1874, April 10, 8·5: May 8, fine red; 8. 1875, May 15, fine ruby; 8. 1876, May 19, fine deep red; 8, at least: June 22, fine red; 7·5.—*Dublin obs.:* Copeland; 1875, July 6, very red; 8: July 16, intense red; 9.—*Addit. obs.:* 1879, June 2, 8·7; red. 1880, June 14, 8·2; decidedly red (D.). Schönfeld; roth. 1888, May 4, 7·0; very red, *var.* ? (Es.).
493	Holden, . .	No. 44. 1881, June 13, good red star; 9 mag.
494	Dunér, . .	Rouge-jaune.
495	Vogel, . . .	(Spect. Beob.): 1881, July 17; gelblich roth.—*E.'s obs.:* 1886, June 4, 6·5; orange red.
496	Holden, . .	No. 45. 1881, June 13, red; 8·5.
497	Webb, . . .	(Private letter); red; 9.—*Addit. obs.:* 1884, Aug. 8, 9·0; pale red (W.). 1881, May 14, no red star in this place (H.). 1885, July 5, 8·0; fine pale red: July 9, 8·0; pale red. 1887, March 27, 8·0; orange red (Es.).
498	***Schj.'s notes,*** .	" Cape obs.: ruby red; 8."—*Addit. obs.:* A. G. C., yellow.
499	"	" Cape obs.: scarlet, or high orange; 8.—*Addit. obs.:* A. G. C., very red.
500	D'Arrest,. .	(A. N., 2016); hellrothgelb.—*Addit. obs.:* 1881, June 5, 6·5; reddish yellow (H.). 1885, June 2, 6·5; pale red (Es.).
501	***Schj.'s notes,*** .	" Cape obs.: remarkable red; 8. Argel., 17158; 8·5. Birmingham (M. N., xxxiv.): 1873, Mai 18, höchstens 9. 1874, April 10, 9–9·5: May 7, 8–9; stets röthlich."—*B.'s addit. obs.:* 1875, May 15, not seen. 1876, April 13, good red, near the moon; 9: May 19, slightly red; 9·5: June 22, reddish; 7·5. *Variable* (?)—*Dublin obs.:* Copeland; 1875, July 16, very deep red; 9·2. Burton; 1876, July 20, very intense red; 8·5.—*Addit. obs.:* 1879, June 2, 8·2; orange: June 19, 8·0; red (D.). 1888, April 17, 8·1; very red (Es.).

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
502	—	—	D. M. + 4°. 3493,	XVII.^{h} 38^{m} 30^{s}	+ 2^{s}·96	+ 4° 23′·4	– 0′·03	8·1
503	—	—	D. M. – 3°. 4177,	41 56	3·16	– 3 36·0	0·03	8·5
504	—	—	D. M. + 4°. 3541,	46 34	2·97	+ 4 30·8	0·02	7·0
505	420	206	. . . .	48 37	3·02	+ 1 48·3	0·02	9·5
506	422	207	. . . .	52 32	3·01	+ 2 43·9	0·01	7·3
507	424	207*a*	. . . .	56 29	3·78	– 27 53·4	0·01	8½
508	—	—	D. M. + 19°. 3509,	58 35	2·59	+ 19 33·0	0·00	7·0
509	—	—	. . . .	59 43	4·34	– 43 24·1	– 0·00	8
510	426	208	. . . .	XVIII. 0 34	2·90	+ 7 5·1	+ 0·00	7·8
511	—	—	. . . .	1 ::	::	– 66 25·0	0·00	—
512	—	—	D. M. + 6°. 3627,	2 1	2·92	+ 6 31·8	0·00	7·5
513	427	209	. . . .	3 25	3·44	– 15 18·0	0·00	8·3
514	—	—	D. M. + 43°. 2890,	3 31	1·81	+ 43 26·6	0·00	8·0
515	—	—	D. M. – 11°. 4545,	3 37	3·35	– 11 44·4	0·01	6·8
516	—	—	D. M. + 12°. 3404,	4 20	2·78	+ 12 23·6	0·01	7·5
517	428	209*a*,	T Herculis, . . .	4 56	2·27	+ 31 0·1	0·01	var.
518	—	—	. . . .	6 34	3·53	– 18 57·9	0·01	—
519	—	—	. . . .	7 11	3·54	– 19 15·9	0·01	—
520	—	—	. . . .	7 19	3·54	– 19 6·9	0·01	—
521	—	—	D. M. + 33°. 3048,	8 10	2·20	+ 33 15·4	0·01	7·3
522	431	—	D. M. + 22°. 3303,	8 15	+ 2·51	+ 22 48·1	0·01	7·5

No.	OBSERVATIONS.	
502	Webb, . . .	1871, Aug. 7, pale ruby; 9: Aug. 31, certainly pale ruby. 1873, Nov. 3, 1876, Aug. 14, pale ruby.—*E.'s obs.:* 1886, May 14, 9·0; pale orange red.
503	Holden, . .	No. 48. 1881, May 20, 23, 8; red. Dunér; rouge-jaune.—*E.'s obs.:* 1886, June 14, June 16, 8·0; pale red.
504	Webb, . . .	1880, Aug. 31, pale ruby, 8; with 9, blue, s. p.—*E.'s obs.:* 1886, May 14, 8·0; fine orange red; a very blue 9·3, s. p.
505	*Schj.'s notes*, .	"Cape obs.: ruby coloured; 9. Scheint nach Birmingham veränderlich (M. N., XXXIV.). Webb bemerkte auch die veränderlichkut."—*B.'s obs.:* 1871, Sept. 4, just tinged with red; 7–8. 1872, May 9, not seen. 1873, April 20, not seen. 1874, April 10, not seen; strong twilight. May 8, not seen; fine sky. 1874, May 15, not seen. 1875, July 25, 26, seems reddish, but too small to be certain; under 10. 1876, April 13, reddish, not over 11 mag. *Webb*, in two trials (1871, Aug. 7; 1873, Sept. 22), failed to see it. It is certainly *variable.* —*Addit. obs.:* 1875, July 16, 9·2; not perceptibly red (C.). 1879, June 17, 9·5 (D.). 1885, July 8, looked for but not found. 1886, April 29, a 10·0 here (Es.).
506	"	"Cape obs.: fine orange; 7·5. Bessel, 1040; 7. D'Arrest (July 1874); nur röthlich. Secchi gialla oro."—*B.'s obs.:* 1872, May 9, 11, faintest tinge of red; 8. 1873, April 20, slightly orange; 7 (near 67 Ophiuchi). 1874, April 11, reddish: May 8, slightly orange; 7–7·5. 1875, May 26, July 26, very pale red; 7·5. 1876, July 11, 13, pale red; 8·5. *Variable?* —*Dublin obs.:* Ball; 1876, Sept. 16, full red.—*Addit. obs.:* 1875, July 17, 7·5; yellow (C.). 1879, June 2, 7·0; orange (D.). 1881, May 14, yellowish red (H.). 1884, June 22, bright 7; fine orange: July 23, 7 ±; very fine deep orange. 1885, June 25, 26, 7·5 (Gemmill). 1885, July 8, fine red; 7·0: July 12, pale red; 7·5. 1886, April 28, 7·5; orange red (Es.).
507	"	"G. C., 4358. Secchi (M. N., XVIII., p. 10); beautiful ruby; 9."—*Addit. obs.:* 1881, May 20, dull red (H.). A. G. C., yellow.
508	Webb, . . .	1880, Sept. 2, a striking line of three stars, 8, 7, 8; white, white, very pale ruby.—*E.'s obs.:* three stars, 8·5, 7·0, blue; 7·5, orange red. Vogel; röthlich gelb. Dunér; jaune-rouge.
509	Russel, . .	(Private letter); 9; orange red. h. 5014.
510	*Schj.'s notes*, .	"Schj., 6539; roth; 8. Bessel, 1248; 7·5."—*B.'s obs.:* 1872, May 11, scarcely red; 7·5. 1874, April 6, not red; 7·5. 1875, May 26, July 26, not red; 8.—*Addit. obs.:* 1879, June 17; 8·0; orange. 1880, June 4; 8·0; no colour (D.).
511	Russel, . .	(Private letter); 9; orange red. h. 5008.
512	Dunér, . .	Rouge-jaune. Vogel (Spect. Beob.); röthlich gelb.—*E.'s obs.:* 1886, June 14; 7·5; pale red.
513	*Schj.'s notes*, .	"D'Arrest; dunkelroth; 8. Ll., 33287; 8. Argel., 17737, '38; 8 und 7·5."—*B.'s obs.:* 1873, May 18, not seen as a red star. 1875, May 26, pale red; 8·3: July 25, pale red; 8. 1876, April 13, not seen. *Variable?*—*Addit. obs.:* 1879, Aug. 15, 8; red, not deep, but striking (Bm.). 1875, July 16, 8·6; deep red: July 27, 8·5; red (C.).
514	Dunér, . .	Rouge-jaune.—*E.'s obs.:* 1887, April 2, 7·7; orange red.
515	Holden, . .	No. 144. 1882·54; 7·0; red.—*E.'s obs.:* 1887, April 24; 7·0; red (cloudy). Konkoly, 1886, Aug. 2, 7·5; gelblich roth. 1889, Aug. 20, 7·0; pale orange red (Es.).
516	Vogel, . . .	(Spect. Beob.); 1881, Aug. 24, roth.—*E.'s obs.:* 1886, June 4, 7·0; orange.
517	*Schj.'s notes*, .	"Schönf. Cat.; stark röthlich." See Gore's Var. Star Catalogue.
518	Holden, . .	No. 148. 1882·54; 9 mag.; orange red. Position approximate.
519	Holden, . .	No. 149. 1882·54; 8·7; very deep dull red.—*E.'s obs.:* 1886, June 27, 9·0; red.
520	Holden, . .	No. 150. 1882·54; 8·8; red. Position approximate.
521	Webb, . . .	1882, Aug. 11, pale ruby; 9.—*E.'s obs.:* 1886, May 26, 8·5; orange red. Can it be variable?
522	Birmingham, .	1876, Oct. 12, red, pale, but certain; 8.—*Addit. obs.:* 1880, May 14, pale yellow (H.). 1885, June 2, 6·5; reddish, *var.*? 1889, April 17, 8·1; pale orange red (Es.).

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
523	—	—	D. M. − 18°. 4862,	xviii.^{h} 8^m 59′	+ 3^s·53	− 18° 57′·9	+ 0′·01	8·7
524	—	—	D. M. − 19°. 4932,	9 6	3·55	− 19 59·9	0·01	9·1
525	—	—	D. M. − 12°. 4974,	11 46	3·38	− 12 54·6	0·02	7·3
526	—	—	. . . .	11 55	3·51	− 18 17·8	0·02	—
527	—	—	. . . .	12 8	3·39	− 13 28·8	0·02	—
528	—	—	D. M. − 12°. 4988,	12 31	3·36	− 12 8·7	0·02	8·5
529	435	210	. . . .	13 49	3·05	+ 0 47·8	0·02	7·9
530	—	—	L. 7681, ...	14 45	3·69	− 24 57·8	0·02	var.
531	436	211	. . . .	16 31	3·07	+ 0 6·3	0·02	7·9
532	437	211*a*	. . . .	16 58	2·45	+ 25 0·3	0·02	7·5
533	439	—	21 Sagittarii . .	18 48	3·57	− 20 36·0	0·03	5·4
534	442	—	D. M. + 38°. 3164,	21 1	2·01	+ 38 40·3	0·03	9·5
535	—	—	D. M. − 21°. 5013,	21 15	3·59	− 21 18·7	0·03	8·7
536	443	212	T Serpentis, . .	23 28	2·93	+ 6 13·6	0·03	var.
537	—	—	D. M. − 21°. 5032,	24 54	3·59	− 21 19·6	0·04	8·5
538	444	212*a*	Y Sagittarii, . .	24 57	3·51	− 18 20·3	0·04	var.
539	—	—	. . . .	25 1	3·49	− 17 29·6	0·04	—
540	445	212*b*	U Sagittarii, . .	25 24	3·53	− 19 12·1	0·04	var.
541	—	—	D. M. + 7°. 3724,	25 37	2·88	+ 8 0·1	0·04	7·6
542	446	213	. . . .	26 27	3·43	− 14 56·7	0·04	6·7
543	—	—	D. M. + 4°. 3785,	27 12	2·97	+ 4 12·7	0·04	7·5
544	447	214	. . . .	27 16	+ 3·19	− 5 14·5	0·04	7·0

No.	OBSERVATIONS.	
523	Holden, . .	No. 152; 1883·57; 7·5; orange red. Gage, 1886, Sept. 17, 8·0; red.
524	Holden, . .	No. 153; 1883·61; 9·5; good red star.
525	Konkoly, . .	1886, Aug. 2, gelblich roth; 7.
526	Holden, . .	No. 55. 1881, May 20; 8; dull red.—*E.'s obs.:* 1889, Aug. 20, 8·0; orange red.
527	Holden, . .	No. 155. 1882·58; deep red; 9·2. Dupl., 9·2, 12; 40″; 265°.
528	Konkoly, . .	1886, Aug. 2, gelblich roth; 7.
529	*Schj.'s notes,* .	"Cape obs.: very red; 8. Ll., 33933; 8. Bessel, 263; 8. Schj., 6662, '63; 9 und 8."—*B.'s obs.:* 1872, May 11, 1873, April 20, scarcely reddish; 8. 1875, May 26, reddish; 8: July 25, reddish; 8·5–9. 1876, April 13, reddish; 8.—*Webb's obs.:* 1873, Sept. 26, Slightly flushed red; 9.—*Addit. obs.:* 1875, July 16, 8·2; full red (C.). 1880, June 10, reddish (D.). 1881, May 14, faintly reddish (H.).
530	Holden, . .	No. 157. 1882·49, orange red; 6·5. A. G. C., orange; *variable.* Gage, 1886, Sept. 17, 7·0; orange red.
531	*Schj.'s notes,* .	"Bond, I., p. 39; red; 7·5. Ll., 33840; 8."—*B.'s obs.:* 1872, May 11, very faint red; 8. 1875, May 26, not red, 7·5.—*Webb's obs.:* 1873, Sept. 26, very pale red; 8·5.—*Addit. obs.:* 1879, June 17, 8·2; yellow (D.). 1881, May 14, faintly reddish (H.).
532	"	"Vermuthlich Secchi's rother stern in *Mem. Sec.*, p. 54; *bellisima stella* rossa. Ll., 33896; 6·5. Bessel, 435; 8." According to Secchi's place in the *Prodromo* the position would be $\alpha =$ XVIII.^{h} 15^m 5^s; $\delta = +25°\ 2' \pm$ (1880).—*Addit. obs.:* 1875, Aug. 3, 8·0; yellowish white (C.). 1879, June 19, 7·7; no colour. 1880, 7·5; no colour (D.). 1881, May 14, no red star 7·5 here (H.). 1885, June 2, no red star here; a 7·5 white; so 1885, June 9; 1887, March 27. Much time was spent in March 1887 in searching for any star which could be identified with this, but with no result. The only red star with III. type spectrum found near Secchi's place was, Es. 211 = D. M. + 25° 3545, the place for 1880 being XVIII^h. 25^m 22^s + 25° 6′·1 (D. M. mag. 9·0). 1887, March 27, 8·5; red.
533	Schmidt, . .	Schmidt, A. N., 1902; red; 6·7. Thome (private letter); very red. Schönfeld; rothgelb. A. G. C., 5·1. Franks; pale orange. 1888, April 17, 5·0; orange (Es.).
534	Burton, . .	(Private letter); ruddy; 8.—*Addit. obs.:* 1880, Aug. 6, 8·0; pale orange ruby. 1882, Aug. 16, deep yellow; 7·5 (W.). 1881, Oct. 15, 7·5; reddish white (Do.). 1886, May 21, 8·0; orange red. 1887, March 27, 8·7; orange. *Variable?* (Es.).
535	Holden, . .	No. 161. 1882, 8·9; red.
536	*Schj.'s notes,* .	"Baxendell (M. N., XXI., p. 68); deep yellowish red." See Gore's Var. Star Catalogue.
537	Holden, . .	No. 163. 1882·52; 8·7; red.
538	*Schj.'s notes,* .	"Schönf. Cat.; röthlich." See Gore's Var. Star Catalogue..
539	Holden, . .	No. 164. 1883·60; 10 mag.; good red.
540	*Schj.'s notes,* .	"Schönf. Cat.; gelbroth." See Gore's Var. Star Catalogue.
541	Vogel,. . .	(Spec. Beob.); 1880, Aug 26, gelblich roth.—*E.'s obs.:* 1886, June 14, 8·0; yellow.
542	*Schj.'s notes,* .	"D'Arrest; rubra; 6·5. Ll., 34257; 6·5. Secchi; bella rosata."—*B.'s obs.:* 1873, April 20, red orange; 6·5. 1875, May 26, fine red orange; 5·5.—*Addit. obs.:* 1879, June 17, 7·5; reddish. 1880, Aug. 2, 6·5; not red (D.). 1882·58; fine orange red; 5·8 (H.).
543	Webb, . . .	1880, Aug. 31, very pale ruby—*E.'s obs.:* 1886, May 6, 8·0; red. 1888, May 8, 7·4; orange red.
544	*Schj.'s notes,* .	"Schj., 6803; roth; 7·5. Ll., 34307; 7. Bessel, 599; 8."—*B.'s obs.:* 1872, May 11, not red; 7·3. 1873, April 20, not red; 7–7·5: May 18, *blue*; 7–7·5: July 20, blue; 7·5.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
544	447	214	. . . .	XVIII.^{h} 27^m 16^s	+ 3^s·19	− 5° 14′·5	+ 0′·04	7·0
545	448	—	D. M. + 36°. 3168,	28 32	2·08	+ 36 54·6	0·04	8·5
546	—	—	D. M. + 38°. 3213,	29 10	2·01	+ 38 45·5	0·04	8·0
547	—	—	D. M. + 4°. 3797,	29 53	2·96	+ 4 51·2	0·04	8·5
548	450	214*a*	. . . .	29 37	3·66	− 23 59·8	0·04	neb.
549	451	214*b*	. . . .	30 12	3·23	− 6 49·8	0·04	7·0
550	—	—	D. M. + 37°. 3173,	31 56	2·05	+ 37 34·6	0·04	8·0
551	453	215	. . . .	32 39	2·40	− 13 52·3	0·05	8·2
552	454	215*a*	. . . .	32 41	2·81	+ 11 21·2	0·05	8·7
553	—	—	D. M. + 8°. 3780,	33 6	2·87	+ 8 44·0	0·05	var.
554	455	216	. . . .	33 37	2·86	+ 9 2·8	0·05	9·2
555	—	—	D. M. + 39°. 3476,	34 28	1·98	+ 39 34·6	0·05	6·5
556	—	—	D. M. − 11°. 4717,	36 22	3·33	− 11 12·8	0·05	8·5
557	—	—	D. M. − 19°. 5134,	36 26	3·54	− 19 23·3	0·05	6·5
558	456	217	. . . .	36 40	3·07	+ 0 3·0	0·05	8·7
559	—	—	. . . .	38 31	2·09	+ 36 29·5	0·06	—
560	457	—	D. M. − 6°. 4869,	38 46	3·23	− 6 38·2	0·06	7·5
561	458	—	D. M. + 36°. 3243,	39 2	2·08	+ 36 51·4	0·06	7·5
562	—	—	D. M. − 6°. 4871,	38 49	3·23	− 6 44·9	0·06	8·8
563	—	—	D. M. − 12°. 5159,	39 24	+ 3· 3	− 12 42·0	0·06	6·7

No.	OBSERVATIONS.	
544	*continued*—	1874, April 11, not red; 7·5. *Variable in colour?*—*Addit. obs.:* 1875, July 16, 7·2; yellow (C.). 1889, Sept. 20, 7·5; pale orange red (Es.).
545	Birmingham, .	1876, April 13 (A. N., 2092); deep crimson; 8·3. From several observations I conclude this star to be a variable of short period, between 8 and 9 mag. The Rev. T. W. Webb considers it scarcely inferior in tint to R Leporis. Father Secchi describes the colour as "*intense.*"—*Addit. obs.:* 1881, Aug. 31, 7·5–7·8: Sept. 15, 7–7·5; brighter than I ever saw it: Sept. 22, 8·0, Oct. 2, 7·5. 1882, April 28, 8·5: May 6, 8·3, May 15, 29, 8·5 (Birm.). 1881, May 14, fine red, not crimson (H.). 1881, Oct. 15, 8·5 very red (Do.). 1885, May 10, 8·0; fiery red, superb (Fr.). 1885, May 1, 8·0; crimson; magnificent. This star is probably a *var.* of the 19 Piscium type (Es.).
546	Webb, . . .	1883, Aug. 24, pale orange ruby, 9 mag.—*E.'s obs.:* 1886, May 21, 8·0; very pale orange red, with 9·0 blue near. 1888, April 17, hardly red.
547	Vogel, . . .	(Spect. Beob.); 1880, Aug. 26, gelblich roth; 7·8.
548	*Schj.'s notes*, .	"h. 3753 = 2015; two red 12 mag. stars."
549	,,	"Schj., 6828; roth; 8. Piazzi, 123; 7. Ll., 34423; 6·5. Bessel, 671; 8."—*Addit. obs.:* 1880, June 14, 8·0; yellow: Aug. 7, 8·8; reddish (D.). 1885, June 9, reddish orange. (Gemmill.). 1889, Sept. 20, 7·0; pale orange red (Es.).
550	Webb, . . .	1882, Aug. 10, 9; pale ruby.—*E.'s. obs.:* 1886, May 21, 8·0; fine orange red, in a lovely field of minute stars. Var.?
551	*Schj.'s notes*, .	"D'Arrest; rubra; 8. Ll., 34507. Bessel, 734; 8."—*B.'s obs.:* 1873, April 20; good red. 1875, May 26, slightly red; 8: July 26; reddish; 8·5–9.—*Addit. obs.:* 1879, June 19, 8·0; reddish. 1880, July 29, 8·5 (D.).
552	,,	"Lamont, z., 196; rubra; 9. Bessel, 757; 8."—*Dublin obs.:* Ball; 1876, Oct. 14, slight red tinge.—*Addit. obs.:* 1875, July 16, 8·5; reddish (C.). 1879, June 17, 8·8: July 28, 8·0; no colour, n. p. of 2 (D.).
553	Espin, . . .	No. 177. Variable; 6·5–9·0; fine red.
554	*Schj.'s notes*, .	"Lamont, z., 194; rubra; 10."—*B.'s obs.:* 1873, April 18, and May 18, not seen.—*Addit. obs.:* 1875, Aug. 1, 8·5; yellow; a double star p. 30^s (C.). 1880, Aug. 9, 9·3; yellow (D.). 1886, July 1, no *red* star here (Es.).
555	Dunér, . .	Rouge-jaune.—*E.'s obs.:* 1886, Nov. 2, 7·0; orange red.
556	Konkoly, . .	1886, Aug. 4; gelblich roth; 8.—*E.'s obs.:* 1889, Aug. 20, 7·3; pale orange red (clouds).
557	Holden, . .	No. 167; 1882·54; strong reddish; 7·5. 1882·58; orange red; 6·5; moonlight. Gage; 1886, Sept. 18, 7·7; light red. A. G. C., 7·0. 1889, Aug. 20, orange red (Es.).
558	*Schj.'s notes*, .	"Bond, I., p. 41; red; Schj., 6898; 8."—*Webb's obs.:* 1873, Sept. 25, pale ruby; 8.—*Addit. obs.*; 1875, July 23, 8·0; red: Aug. 5, 8·4; full orange (C.). 1881, May 14, yellowish (H.). 1887, March 27, 8·8; orange red (Es.).
559	Gage, . . .	1880, Sept. 5, very red. 1884, Sept. 20, 7.0; very red: Oct. 12, 8·0.—*E.'s obs.:* looked for repeatedly, 1886, '87, '88, but not seen. The star D. M. + 36°. 3239, 7·0 mag., lies 10^s p. 3′ s.
560	Birmingham, .	Red orange; 7·5. Ll., 34746.—*Addit. obs.:* 1882, Sept. 15, 8·0; pale ruby (W.). Schönfeld; röthlich gelb. 1889, Sept. 20, 7·0; orange red (Es.).
561	Webb, . . .	(Private letter); orange ruby; 9.—*B.'s obs.:* 1876, April 13, fine red; 8–8·5.—*Addit. obs.:* 1880, Aug. 2, 9; pale ruby. 1882, Sept. 11, 8·5; orange red (W.). Mr. Webb's previous observations were on the following dates:—1873, Aug. 16, 7·0; pale ruby: Aug. 19, 8·0: Sept. 27, 9·0; orange ruby (W.). 1881, May 14, no really red star in this place (H.). 1881, Oct. 15, 7·8; pale red (Do.). 1885, April 29, May 1, May 12, 8·0; fine red (Es.). 1885, May 10, 8·5; red (Fr.).
562	Webb, . . .	1882, Sept. 15; 10; red.
563	Konkoly, . .	1886, Aug. 4; 7·5; gelblich roth.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
564	459	—	D. M. + 39°. 3505,	XVIII. 39^{m} 37^{s}	+ 2^{s}·00	+ 39° 11′·5	+ 0′·06	6·5
565	460	218	T Aquilæ, . . .	40 28	2·87	+ 8 37·7	0·06	var.
566	461	—	D. M. + 33°. 3192,	40 50	2·22	+ 33 4·6	0·06	7·7
567	462	218*a*	R Scuti, . . .	41 37	3·21	− 5 49·4	0·06	var.
568	463	—	D. M. + 18°. 3817,	41 52	2·63	+ 18 35·1	0·06	6·4
569	—	—	D. M. − 6°. 4922,	43 48	3·21	− 6 2·0	0·06	6·8
570	464	219	. . . .	43 57	3·26	− 8 1·8	0·06	7·1
571	—	219*a*	. . . .	44 49	3·06	+ 0 39·9	0·06	—
572	465	220*a*	. . . .	47 13	2·86	+ 9 6·1	0·06	9·0
573	466, 467	220	ν′ Sagittarii, . .	47 32	3·62	− 22 52·8	0·06	6·0
574	469	220*b*	. . . .	49 57	2·86	+ 9 6·0	0·07	9·0
575	472	—	D. M. + 17°. 3779,	51 15	2·65	+ 17 58·4	0·07	5·9
576	473	221	. . . .	51 56	3·06	+ 0 18·6	0·07	9·2
577	476	—	D. M. + 38°. 3362,	53 23	2·03	+ 38 39·1	0·08	7·6
578	475	222	. . . .	53 31	2·74	+ 14 12·9	0·08	9·0
579	—	—	D. M. + 40°. 3545,	55 11	1·96	+ 40 31·8	0·08	6·5
580	477	—	D. M. + 22°. 3549,	55 19	2·53	+ 22 39·7	0·08	6·5

No.		OBSERVATIONS.
564	Webb, . . .	(Or Dawes ?); red orange; 7 *B.'s obs.:* red orange, with small *comes*. Discovered independently by Burton, 1872, April 12, who found it very red, with a hazy companion.—*Addit. obs.:* 1878, April 4; 8·0; pale red. 1884, Aug. 22, 9; decided ruby (W.). 1881, Oct. 15; 7; reddish white (Do.). 1878, April 4, 8·0; pale red. *Variable* ? (Es.).
565	*Schj.'s notes*, .	"Cape obs.: ruddy purple; 9. Ist nicht von Birmingham gesehen (M. N., xxxiv.)."—*Webb's obs.:* 1873, Sept. 22, pale ruby; 9·5. See Gore's Var. Star Catalogue.
566	Birmingham, .	1876, Oct. 31, pale red, in very bright moonlight; 8·5.—*Addit. obs.:* 1873, Nov. 3, pale orange red (W.). 1881, Oct. 15, 8; white (Do.). 1887, March 27, 8·0; orange red (Es.).
567	*Schj.'s notes*, .	"Schönf. Cat.; roth." Schm., A. N., 1902; red. See Gore's Var. Star Catalogue.
568	Birmingham, .	Red, or very deep orange; 7.—*Addit. obs.:* 1879, Oct. 9, pale orange red; 7. 1876, Oct. 14, 8; orange ruby (W.). 1886, May 14, 7·2; orange red: July 1, 6·0; orange red; *var.* ? (Es.).
569	Webb, . . .	1882, Sept. 15, 7·5; orange red.
570	*Schj.'s notes*, .	"Cape obs.: most remarkable red; 8. D'Arrest (21 Mai, 1866); schön roth. Birmingham (M. N. xxxiv.); 1873, April 18, 7·5–8: Sept. 23, 7–8. 1874, May 8, wenigstens; 8. Immer, '*fine orange red.*'"—*B.'s addit. obs.:* 1875, May 26, fine red; 7–7·5: July 26, very fine red. 1876, June 22, good red; 7·5. Forms preceding angle of a beautiful triangle containing seven principal, and several smaller stars: July 14, fine ruby red; 8: July 26, fine crimson; 8. *Variable* (?).—*Webb's obs.:* 1873, Sept. 22, fine ruby; 9·5.—*Addit. obs.:* 1879, Oct. 8, deep red; 8–8·3 (Bm.). 1880, July 29, 9·5 (D.). 1884, Aug. 20, 28, Nov. 7, very red; 8 mag. (Gemmill). 1885, June 14, deep red; small (Fr.). 1886, April 28, 7·0; very red; probably a *var.* of the 19 Piscium type (Es.).
571	"	"Bond, ii., p. 15, red ? 9·5."—*Addit. obs.:* 1875, Aug. 1; 10 mag. (C.). 1880, Aug 2, 9·7: Aug. 9, 9·8 (D.).
572	"	"Lamont, z., 883; roth."—*Addit. obs.:* 1879, Oct. 8, not seen (Bm.). 1879, July 26, 9·0; Reddish (D.). 1881, May 14, 8; red, near this place (H.). 1886, July 1, 9·0; not red; an 8 mag. orange 16^s·7 f. on parallel (Es.).
573		Of two stars near ν′ Sagittarii, referred to in the *Storia Cel.*, vol. vii., p. 17, Schj. says that one of them is Ll., 35103; 8 mag.: and the other—the red one—is, perhaps, to be found in the Markree Cat., i., p. 96. It is No. 1713 in the Washington Cat., 1862, and 7 mag. —*Addit. obs.:* 1875, July 25, 7·0; yellow. Aug. 18, red, or full orange (C.). The Dublin obs. apparently refer to ν′ Sagittarii, which is Bm. 466. Schmidt, A. N., 1902; red.
574	*Schj.'s notes*, .	"Lamont, z., 883; roth."—*B.'s obs.:* 1876, Sept. 26, very pale red; 8.—*Dublin obs.:* Copeland; 1875, Sept. 8, not red; 9.—*Addit. obs.:* 1879, Oct. 8, palest red tinge; 9 (Bm.). 1879, June 17, 9·0 f. of 2: Aug. 6, 9.0; reddish (D.). 1886, July 1, 8·5; not red (Es.).
575	Birmingham, .	Pale red, with orange cast; 6·8.—*E.'s obs.:* 1885, May 1, orange. 1886, July 1, 6·3; orange, with fine pale blue 7·0, 7′ n.
576	*Schj.'s notes*, .	"Bond, i., p. 51; garnet red; 9·5."—*Webb's obs.:* 1871, Aug. 19, pale garnet; 10.—*Addit. obs.:* 1875, July 21, 9·0; red. Aug. 5, 8·6; full red: Aug. 18, 9·1; full red (C.). 1881, May 14, red (H.). 1887, Sept. 7, 8·0; very red (Es.).
577	Burton, . .	(Private letter); 1872, April 12, reddish orange; 7·5.—*Addit. obs.:* 1881, Oct. 15, 8; reddish (Do.). 1886, April 28, 8·0; orange red: July 2, 7·5; pale orange red (Es.).
578	*Schj.'s notes*, .	"Lamont, zone 199; rubra; 8. Birmingham (M. N., xxxiv.): 1872, May 16, 8. 1873, April 6, 9–9·5. 1874, May 8, 9·5–10."—*B.'s addit. obs.:* 1875, July 26, fine red; 9–9·5. 1876, June 25, pale red; 9·5: July 31, fine red; 8.—*Webb's obs.:* 1873, Sept. 25, fine ruby; 9·5.—*Dublin obs.:* Copeland; 1875, July 23, fiery red; 9. Burton; 1876, July 19, strong red.—*Addit. obs.:* 1880, Aug. 2, 9·0; red (D.). 1881, May 14, good red star, with *comes*, 30″ (H.). 1884, Aug. 2, 9·0; deep crimson. 1885, Aug. 14, 9½; ruby. 1886, June 14, equal a star n. (Gemmill). 1885, July 5, 8·0. 1886, July 1, 8·5. 1887, March 27, 8·3; all very red. Possibly a *var.* of the 19 Piscium type (Es.).
579	Dunér, . .	Rouge-jaune.
580	D'Arrest, . .	A. N., 2016; auffällig gelbroth.—*B.'s obs.:* fine orange.—*Addit. obs.:* 1886, July 2, 7·0; pale orange red (Es.).

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
581	480	222*a*	. . . .	XVIII.^{h} 57^{m} 4^{s}	+ 2^{s}·88	+ 8° 12′·9	+ 0′·08	6·5
582	—	—	D. M. – 22°. 4958,	57 6	3·62	– 22 52·3	0·08	8·5
583	482	222*b*	. . . .	58 14	2·89	+ 8 8·0	0·08	7·8
584	483	222*c*	. . . .	58 32	3·20	– 5 50·8	0·08	7·0
585	484	223	. . . .	58 59	3·06	+ 0 21·2	0·08	9·5
586	—	—	D. M. + 23°. 3551,	XIX. 0 11	2·52	+ 23 9·1	0·09	8·7
587	486	224	R Aquilæ, . . .	1 4	2·89	+ 8 3·8	0·09	var.
588	—	—	A. G. C., 26201, .	2 13	3·96	– 34 28·5	0·09	8½
589	487	225	. . . .	4 3	2·50	+ 24 0·3	0·09	7·0
590	—	—	D. M. – 14°. 5317,	5 40	3·41	– 14 45·9	0·09	6·8
591	—	—	D. M. – 12°. 5316,	8 0	3·37	– 12 16·1	0·10	8·2
592	488	225*a*	T Sagittarii, . .	8 48	3·46	– 17 9·0	0·10	var.
593	489	226	R Sagittarii, . .	10 14	3·52	– 19 30·0	0·10	var.
594	490	—	D. M. + 18°. 4011,	10 42	2·65	+ 18 19·9	0·10	6·3
595	—	—	D. M. – 16°. 5272,	12 51	3·44	– 16 6·5	0·10	6·8
596	492	—	. . . .	14 49	2·43	+ 27 3·2	0·11	—
597	493	—	D. M. + 22°. 3660,	14 51	2·55	+ 22 22·0	0·11	7·7
598	—	—	D. M. + 17°. 3940,	16 47	2·68	+ 17 27·0	0·11	9·5

No.		OBSERVATIONS.
581	*Schj.'s notes*, .	"Lamont, z., 781; roth. Ll., 35562; 6. Bessel, 1408; 7."—*B.'s obs.:* 1876, Sept. 26, orange; 7.—*Dublin obs.:* Copeland; 1875, July 25, reddish; 7.—*Addit. obs.:* 1875, Aug. 17, 7·0; full yellow (C.). 1880, Aug 9, 6·5; orange (D.). 1886, July 2, 7·0; orange red (Es.).
582	Holden, . .	No. 175; 1882·61, 8·2; red. A. G. C., 7½.
583	*Schj.'s notes*, .	"Lamont, z., 781; roth. Ll., 35624; 7·5. Bessel, 1445; 8. Schj., 7125; 8."—*B.'s obs.:* 1876, Sept. 26, not red.—*Dublin obs.:* Copeland; 1875, Aug. 18, white.—*Addit. obs.:* 1875, July 21, yellow (C.). 1886, July 2, 8·0; yellowish white (Es.).
584	"	"Ll., 35611; 7·5. Bessel, 1442; sehr roth; 7·5. Schmidt, A. N., 1902; und Vogel, A. N., 2000; glühend feurroth. D'Arrest; Aug., 1874, auffallend roth. Knott, A. N., 1862, fine coloured red star."—*B.'s obs.:* 1876, Sept. 16, very fine red; 7·5.—*Dublin obs.:* Copeland; 1875, July 16, deep red. *Variable* (?).—*Addit. obs.:* 1865, July 26, colour, truly striking and wonderful. 1876, Oct. 31, 8 ±; very fine. 1882, Sept. 11, 8·0; very fine ruby (W.). 1880, Aug. 6, 7·0; copper red (D.). Gemmill's obs.: 1884–1886 show variation.—*E.'s obs.:* 1878, Oct. 22, 8·0. 1880, Aug. 28, 7·5; Aug. 31, 7·8; very red. 1885, July 9, 7·0: July 12, 7·5. 1886, April 26, 7·5. For remarks on the colour of this star see E. M., Nov. 25, 1881, &c. This star is certainly variable, and probably belongs to the 19 Piscium type. Schönfeld, sehr roth. Baxendell (private letter); remarkable red. A. G. C., 7¾; crimson.
585	"	"Bond; reddish; 9·5."—*Addit. obs.:* 1875, Aug. 5, 9·2; red (C.). 1880, Aug. 7; 9·5 (D.). 1886, July 2, 9·0; red.
586	Webb, . . .	1871, Oct. 12; 9 mag.; pale red. 1876, Aug. 16, 9; very pale red.
587	*Schj.'s notes*, .	"Auwers, A. N., 1238; roth." See Gore's Var. Star Catalogue.
588	A. G. C., . .	Crimson.
589	*Schj.'s notes*, .	"Con. des Temps, xv.; rouge. Ll., 35928, '29; 7, und 6. Bessel, 49; 7."—*B.'s obs.:* 1872, and Sept. 1873, pale red, with small blue *comes*. 1874, Sept. 23, good red; 6. 1875, July 25, splendid red orange: 6·5; *comes* blue. 1876, June 22, very pale red; 7·5.—*Addit. obs.:* 1875, July 23, 8·0; red: Aug. 5, 7·3; deep orange: Aug. 18, 8·0; orange (C.). 1880, July 28, 6·5; orange (D.). 1881, May 14, yellow red; *comes* not especially blue (H.).
590	A. G. C., . .	Crimson.
591	Konkoly, . .	1883, Aug. 27, 6·0; gelblich roth. Ll., 36055; 8·5.
592	*Schj.'s notes*, .	"Schönf. Cat.; röthlich." See Gore's Var. Star Catalogue. The place is from the A. G. C. The following are the other determinations:— Pogson (Madras Observations, 1864), $\alpha = \text{xix.}^{h}\ 9^{m}\ 53^{s}\ \delta = -17^{\circ}\ 9'{\cdot}8$ (1890). Schönfeld (Südl. D. M.). $\alpha = \text{xix.}\ 9\ 53\ \delta = -17\ 9{\cdot}9$ (1890).
593	"	"Auwers, A. N., 1238; röthlich." Schönf. Cat.; rothgelb."—*Webb's obs.:* 1873, Sept. 26, pale orange. See Gore's Var. Star Catalogue.
594	Birmingham, .	1876, Sept. 29, pale red; 7.—*Addit. obs.:* Vogel (Spec. Beob.). 1881, Sept. 20, röthlich gelb.—*E.'s obs.:* 1886, July 2, 6·8; pale orange red.
595	Holden, . .	No. 179; 1883·66; red; 8·5; sky very hazy. Arg., 7. Lam., 7–8. This star is perhaps identical with Ormond Stone's Red Star (private letter to Mr. Birmingham), found by him, 1880, Aug. 6; mag. 6·5. Place, $\alpha = \text{xix.}^{h}\ 10^{m} \pm\ \delta = -16^{\circ}.\ 7' \pm$, and observed by Birmingham, 1880, Aug. 27, as a remarkable fine red 7·5–8. (See "Nature," vol. xxii., p. 408.)
596	Buckingham, .	(Webb's C. O., 3rd edition, p. 285); red; 7.—*B.'s obs.:* the position closely agrees with D. M., + 26°. 3529; 9 mag. If it is the same star it must be variable.
597	Webb, . . .	(Private letter); red orange; 8.—*Addit. obs.:* 1876, Aug. 16; 8 mag.; pale ruby (W.). 1886, July 2, 7·5; orange red (Es.).
598	Vogel, . . .	(Spec. Beob.); 1881, Sept. 20, gelblich roth. Espin, No. 93. 1885, Sept. 27, 9·5; very fine red: Oct. 27, 9·5: Dec. 7, fully 8·5, *var.*? 1886, April 26, 9·5: May 14, 8·7: June 13, 8·3: June 16, 22: July 2, 8·4: Aug. 20, 8·7: Nov. 2, 17, 8·6. 1887, March 27, 9·4. 1888, May 4, 8·8.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
599	—	—	D. M. + 35°. 3598,	XIX.^{h} 19^{m} 55^{s}	+ 2^{s}·16	+ 35° 58′·3	+ 0′·11	7·9
600	—	—	D. M. + 49°. 2999,	21 39	1·58	+ 50 1·0	0·12	7·5
601	496	—	D. M. + 19°. 4017,	21 40	2·62	+ 19 40·0	0·12	6·2
602	497	—	D. M. + 35°. 3614,	22 0	2·16	+ 35 58·6	0·12	8·0
603	498	—	D. M. + 1°. 4004,	22 18	3·03	+ 1 57·2	0·12	7·8
604	499	—	D. M. + 2°. 3904,	24 40	3·01	+ 2 40·6	0·12	6·9
605	500	227	36 Aquilæ, . . .	24 55	3·14	− 3 1·1	0·12	5·7
606	—	—	D. M. + 28°. 3363,	25 18	2·36	+ 28 30·1	0·12	8·2
607	502	229	. . . .	25 28	− 2·04	+ 76 18·6	0·12	6·5
608	—	—	D. M. + 45°. 2906,	25 32	+ 1·79	+ 45 49·2	0·12	8·6
609	—	—	D. M. − 1°. 3763,	26 2	3·10	− 1 30·6	0·12	8·8
610	504	—	D. M. + 4°. 4152,	27 42	2·97	+ 4 47·8	0·12	7·2
611	505	228	. . . .	28 1	3·44	− 16 36·7	0·12	7·2
612	—	—	D. M. − 18°. 5432,	30 40	3·49	− 18 28·7	0·13	5·4
613	507	229*a*	R Cygni, . . .	33 52	1·61	+ 49 57·1	0·13	var.
614	508	229*b*	. . . .	35 21	3·06	+ 0 26·9	0·13	8·0
615	—	—	D. M. + 69°. 1058,	35 47	− 0·21	+ 69 33·1	0·14	8·0
616	509	—	D. M. + 32°. 3522,	36 44	+ 2·30	+ 32 21·8	0·14	8·0
617	—	—	D. M. − 14°. 5518,	36 50	3·39	− 14 28·9	0·14	8·6

No.	OBSERVATIONS.	
599	Dunér, . .	Rouge-jaune.
600	Espin, . . .	No. 94. 1885, July 8, 7·0; fine red. 1887, March 23, orange red; 7·0; May 13, very red; 7·3; a blue star, 6·8, near.
601	Webb, . . .	(Private letter); fine red orange; 6·5.—*Addit. obs.:* Ball (private letter to Mr. Birmingham); red, and slightly yellowish red.—*E.'s obs.:* 1886, July 2, 6·0; orange red, with *comes*, 10·0. Σ 2521; 5·5; egregie aurea.
602	Webb, . . .	(Private letter); red; 8.—*Addit. obs.:* 1873, Sept. 25, 9·5; pale ruby. 1876, July 20, 8·5; pale ruby at 205°; 6′; from 4 Cygni. Aug. 15, pale ruby; 8·5 (W.). 1881, May 14, yellowish red (H.). 1885, July 4, 7·0; fine pale red: July 8, very pale red. 1886, July 2, 8·0; pale red. 1888, Oct. 3, orange red; 8·5 (Es.).
603	Birmingham, .	1876, Aug. 10, orange; 8·5; *variable* (?).—*Addit. obs:* 1885, June 29, 6·8; bright orange: June 30, July 1, 6·5; good orange (Gemmill). 1886, July 1, 7·5; orange red: July 2, 8·0; pale red. Apparently *var.* (Es.).
604	Birmingham, .	1876, Aug. 10, red orange; 5.—*Addit. obs.:* 1878, Sept. 20; 8 mag.; orange; 11 mag. *comes*, n. (W.). 1886, July 1, 7·5; pale orange red, with *comes*, 10·0: July 2, 6·5; fine orange red (Es.).
605	*Schj.'s notes,*	"Lamont, z., 258; rubra; 7. Ll. 36870, '71, '73; 6, 5·5, 5. Bessel, 567; 6. Schj., 7371; 5·5. Secchi; bella rosata."—*B.'s obs.:* 1873, April 18, pale orange; 7. 1876, July 14, yellow orange; 6.—*Webb's obs.:* 1873, Sept. 26, good orange; 5. Schmidt, A. N., 1902; deep red.—*Dublin obs.:* Burton; 1876, July 22, fine orange red; 6·5: July 24, ruddy; 7·5. *Addit. obs.: var.* (Bm.). 1875, July 21, 7·0; yellow: July 27, 7·5; full orange: Aug. 17, 6·0; yellow (C.). 1879, Aug. 6, 6·8; yellow (D.). 1886, July 2, 5·0; pale orange red (Es.).
606	Webb, . . .	1876, Sept. 8, double; 8, 12; 85° ± 30″; very pale ruby, and blue.—*E.'s obs.:* 1887, Dec. 7, 8·5; pale orange red; 9·3; blue.
607	*Schj.'s notes,* .	"Argel., 19336; sehr roth; 6·5. Ll., 37241; 7·5. Fedor., 3209; 8."—*B.'s obs.:* 1872, July 14, fine red; 6. 1873, April 18, red orange; 6·5. 1874, May 8, red orange; 6·5. 1876, June 26, red orange; 6·5.—*Dublin obs.:* Burton; 1876, July 19, strong red; 9. *Variable* (?).—*Addit. obs.:* 1875, July 25, 7·0; red: July 28, 7·5; deep red: Aug. 18, 6·5; red (clouds) (C.). 1879, Aug. 14, copper red (D.). 1885, July 30, fine orange red (Fr.). 1886, July 2, 7·0; very orange red; perhaps a variable of the 19 Piscium type (Es.).
608	Espin, . . .	No. 179. 1886, June 4, 8·0; very red. Sept. 30, 8·6: Nov. 24, 8·5: Nov. 30, 8·0; *var.* ?
609	Webb, . . .	1877, Nov. 10, very pale ruby; 8·5.—*E.'s obs.:* 1885, Sept. 25, 7·0; orange red, *var.* ?
610	Birmingham, .	1876, Aug. 13, red orange; 7.—*Addit. obs.:* 1886, July 1, 6·8; orange red (Es.). Dunér; rouge-jaune.
611	*Schj.'s notes,* .	"Cape obs.: good ruby; 7. Arg., 19721."—*B.'s obs.:* 1873, pale red; 7·8. 1876, July 14, fine red; 7·5.—*Webb's obs.:* 1873, Sept. 26, fine ruby; 7·5.—*Addit. obs.:* 1875, July 23, 7·0; red: Aug. 3, intense red: Aug. 25, 7·8; deep red (C.). 1879, July 26, 8·0; red (D.). 1881, Aug. 21, 7·7; fine red; 1882·61, red; 7·0. 1882·63, ; 7·0; red. 1883·65, very red; 7; sky hazy. 1883·66, very red; 8; sky hazy (H.). 1885, June 13, orange (Fr.). 1886, July 2, 7·5; red; an 8·0; $4^{s}\cdot 6$ p., $5'\cdot 5$ n. (Es.).
612	A. G. C., . .	Crimson; 5·8.—*E.'s obs.:* 1888, Aug. 13, 5·0; orange. 1889, Aug. 20, 6·0.
613	*Schj.'s notes,* .	"Schönf. Cat.; sehr roth. Auwers; violett. Arg. VI., p. 153; roth." See Gore's Var. Star Catalogue.
614	,,	"Bond; reddish; 7·5.—*Addit. obs.:* 1879, Aug. 6, 7·7; yellow. 1880, July 29, 8·2; orange (D.). 1886, July 1, 8·0; pale orange. 1889, Aug. 13, 8·0; very pale orange red (Es.).
615	Dunér, . .	Rouge-jaune.
616	Birmingham, .	1874, May 8, full red; 8·5.—*Addit. obs.:* 1881, May 14, red (H.). 1885, Jan. 6, ruddy orange (Fr.). 1885, July 12, 7·5; red: Dec. 7, 7·5; very orange red. 1886, June 27, 7·8; very orange red (Es.).
617	Holden, . .	No. 181. 1883·65; 9; yellowish red, *comes*, 12; 60°; 20″.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
618	510	230	. . . .	xix.^{h} 39^{m} 5^{s}	+ 2^{s}·97	+ 4° 42′·9	+ 0′·14	7·5
619	511	—	D. M. + 12°. 4060,	39 29	2·79	+ 12 58·0	0·14	7·4
620	—	—	D. M. + 18°. 4216,	39 37	2·67	+ 18 19·4	0·14	7·0
621	513	—	D. M. + 44°. 3232,	41 18	1·88	+ 44 39·5	0·14	8·0
622	—	—	D. M. – 12°. 5541,	42 43	3·34	– 12 35·5	0·14	6·5
623	514	—	. . . .	42 57	1·87	+ 44 51·0	0·15	var.
624	515	—	D. M. + 22°. 3812,	43 27	2·57	+ 22 29·7	0·15	7·7
625	516	231	. . . .	43 35	3·06	+ 0 25·6	0·15	9·5
626	517	231*a*	S Vulpeculæ, . .	43 53	2·46	+ 27 0·8	0·15	var.
627	—	—	D. M. – 13°. 5499,	45 37	3·36	– 13 18·9	0·15	6·3
628	518	232	χ^2 Cygni, . . .	46 20	2·31	+ 32 38·2	0·15	var.
629	—	—	D. M. – 11°. 5162,	46 22	3·31	– 11 14·3	0·15	7·8
630	—	—	D. M. + 37°. 3636,	46 51	2·16	+ 37 33·2	0·15	7·0
631	—	—	. . . .	47 46	2·41	+ 29 7·4	0·15	neb.
632	520	233	. . . .	50 56	3·07	+ 0 20·3	0·15	9·5
633	—	—	D. M. – 3°. 4757,	52 46	3·15	– 3 50·9	0·16	6·8
634	521	—	D. M. + 43°. 3425,	53 38	1·94	+ 43 57·7	0·16	8·2
635	—	—	D. M. + 25°. 4062,	55 49	2·51	+ 25 36·3	0·16	9·0
636	523	—	D. M. + 0°. 4386,	55 54	3·07	+ 0 21·6	0·16	8·8
637	—	—	D. M. + 36°. 3815,	56 39	2·22	+ 36 16·2	0·16	8·7
638	—	—	. . . .	56 41	2·37	+ 30 31·3	0·16	—
639	524	—	D. M. + 36°. 3818,	56 54	2·20	+ 36 48·4	0·16	8·5
640	—	—	Z Cygni, . . .	58 20	1·66	+ 49 44·2	0·16	var.

No.	OBSERVATIONS.	
618	*Schj.'s notes*, .	"Schj., 7572; roth; 8. Ll., 37504; 7·5. Bessel, 958; 9. Wolfers, Acad. Sternk.; 8·5. Secchi; rossina."—*B.'s obs.:* 1874, Sept. 23, very faint red; 7.—*Webb's obs.:* 1873, Sept. 25, scarcely coloured; 9. A *comes*, s. p., 14 mag. *Variable* (?).—*Addit. obs.:* 1875, July 23, yellowish: Aug. 1, 7·5; red orange: Aug. 25, very deep orange (C.). 1879, Aug. 14, very pale yellow (D.). 1886, July 1, 8·0; pale orange, *comes*; 10; s. p. (Es.).
619	Webb, . . .	(Private letter); red; 7.—*Addit. obs.:* 1881, May 14, reddish. 1886, June 13, 7·0; red; a 6·5 blue near, and a 9·5 between. 1888, Aug. 13, 8·5; orange (Es.).
620	Webb, . . .	1876, Oct. 14, very pale ruby, or orange, 9. Vogel (Spect. Beob.); 1881, Sept. 23, röthlich gelb. 1888, May 4, 7·4; orange red: Aug. 13, 7·0; pale orange red (Es.).
621	Webb, . . .	(Private letter); pale red; 8·5.—*B.'s obs.:* pale red; 8.—*Addit. obs.:* 1885, July 24, 7·5; orange: Nov. 17, Dec. 15, 8·0; orange (Es.).
622	Konkoly, . .	1883, Aug. 27, 7; gelblich roth.
623	Birmingham, .	1870, Aug. 19, red; 10. Webb, Sept. 1, confirmed B.'s obs., but the star not seen subsequently.—*Addit. obs.:* 1885, Sept. 27, Nov. 17, Dec. 15, not seen. A faintly reddish star, 10·0 mag. (D. M., + 44°. 3242; 9·2), at first mistaken for B.'s star. D. M. star lies 12^{s}·7 p.; 3′·8 s. of B.'s star. 1886, Jan 15, a tiny star, 11·5 in B.'s place.
624	Webb, . . .	(Private letter); red orange.—*B.'s obs.:* 1876, Aug. 22, fine orange; 7·8.—*Addit. obs.:* 1876, Aug. 16, pale ruby; 8·5 (W.). 1888, Aug. 13, 7·0; orange red (Es.).
625	*Schj.'s notes*, .	"Bond, I., p. 91, red; 9·5."—*Addit. obs.:* 1875, July 25, 9·5; reddish: July 28, 9·5; not red (C.). 1879, Sept. 13, 9·5 (D.). 1888, Aug. 13, 9·5; barely flushed (Es.).
626	"	"Schönf. Cat.; gelbroth." See Gore's Var. Star Catalogue.
627	Holden, . .	No. 183. 1883·65; 7·5; orange red. Bessel; 6–7. Konkoly; 1883, Aug. 27, gelblich weiss; 7.
628	*Schj.'s notes*, .	"Auwers, A. N., 1239; roth. Schönf. Cat.; sehr roth." Schmidt; full red. *Variable* (?).—*B.'s obs.:* 1873, April 25, pale yellow; 7·7: July 21, good red; 9. 1874, May 9, pale yellow, 7–7·5. *Strikingly variable in colour.*—*Webb's obs.:* 1871, Oct. 13, superb red; quite equal to R Leonis; 9. 1872, Sept. 20, only pale reddish orange; 6: Oct. 3, more decided red: Nov. 7, distinctly ruby; 7·5. 1873, Nov. 3, orange ruby; 6. E.'s obs., in various years, sometimes quite red, at others only pale orange red. See Gore's Var. Star Cat.
629	Konkoly, . .	1883, Aug. 27, gelblich roth.
630	Dunér, . . .	Rouge-jaune. Espin, No. 106. 1885, June 30, 7·0; red: July 12, 7·0; pale red.
631	Earl of Rosse,	Obs. of Neb., p. 154, 1871, Sept. 4, one star 12 mag.; rather reddish (G. C., 4518).
632	*Schj.'s notes*, .	"Bond, I., p. 81; reddish; 10."—*Addit. obs.:* 1875, July 25, 9·5; reddish: July 28, 9·0; red: Aug. 1, 9·0; reddish (C.).
633	Konkoly, . .	1883, Sept. 3, 4, 7 mag.; gelblich roth.
634	Webb, . . .	C. O., 3rd ed., p. 239; red; 9.—*Addit. obs.:* 1877, Dec. 24, 8·5; pale red (W.). 1885, Jan. 6, splendid, like a drop of blood (Fr.). 1887, April 17, 7·4 (a 7·9 blue 20^{s} p. 0′·5 n.); very red: Ang. 21, 7·7; very red, probably a *var.* of the 19 Piscium type (Es.).
635	Webb, . . .	1877, Oct. 4, pale ruby; 9; *comes*, 10·5, blue, 30″ n.
636	Harvard Zones,	Burnham (M. N., XXXVI.), No. 7; red; 9–10.
637	Webb, . . .	1876, Aug. 8, ruby; one of a beautiful group. Lucida; white, 7 mag.: Aug. 11, small companions, 10·5, 11, 12; 230°, 245°, 250°, with a 13 mag. at 330°: Sept. 8, colour very distinct. 1878, Sept. 11, 10 mag., clear colour.—*E.'s obs.:* 1886, June 21, lovely group; 9·0, red; 9·2, blue, and a 9·5 and 7·0 near. 1887, Dec. 7, 9·0; red; lovely group. Same, 1888, May 13.
638	Espin, . . .	No. 181. 1886, Sept. 22, Nov. 18, 9·3; very red.
639	Birmingham, .	1876, Aug. 19, red; 9·5.—*Addit. obs.:* 1876, Oct 25, 9. 1886, June 24, 8½; fine red (Fr.). 1885, June 30, 8·5; pale red. 1886, June 27, 8·5; very pale red. (Es.).
640	Espin, . . .	217. Discovered, 1887, March 23, as 7·5, red (Wolsingham Observatory Circular, No. 16), and subsequently fading to below 13·0 mag. 1888, April 17, 12·0 mag.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
641	—	—	D. M. + 37°. 3744,	xix.^{h} 59^{m} 41^{s}	+ 2^{s}·17	+ 38° 1′·1	+ 0″·17	7·2
642	526	234	. . . .	xx. 0 11	3·67	− 27 34·3	0·17	8
643	527	234*a*	. . . .	0 14	2·64	+ 20 20·2	0·17	8·9
644	528	235	. . . .	1 38	5·09	− 60 15·2	0·17	—
645	529	—	D. M. + 34°. 3874,	2 30	2·28	+ 34 35·5	0·17	8·5
646	531	235*a*	S Cygni, . . .	3 13	1·26	+ 57 40·1	0·17	var.
647	—	—	D. M. + 35°. 3985,	4 40	2·25	+ 35 49·6	0·17	8·0
648	532	236	R Capricorni, . .	5 8	3·37	− 14 35·7	0·17	var.
649	533	237	. . . .	5 56	2·07	+ 41 10·2	0·17	9·5
650	535	—	D. M. + 47°. 3031,	6 7	1·83	+ 47 31·5	0·17	9·3
651	—	—	D. M. + 35°. 4002,	6 14	2·24	+ 35 37·6	0·17	9·5
652	—	—	D. M. + 35°. 4003,	6 16	2·26	+ 35 32·4	0·17	9·2
653	536	237*a*	S Aquilæ, . . .	6 34	2·76	+ 15 17·6	0·18	var.
654	—	—	. . . .	6 57	2·25	+ 35 47·1	0·18	—
655	—	—	D. M. − 13°. 5619,	8 59	3·35	− 13 43·0	0·18	7·0
656	540	337*b*	R Sagittæ, . . .	9 2	2·74	+ 16 23·6	0·18	var.
657	541	—	D. M. + 38°. 3957,	9 24	2·18	+ 38 23·7	0·18	8·2
658	542	237*c*	R Delphini, . .	9 36	2·90	+ 8 45·3	0·18	var.
659	545	238	[V] Capricorni, .	10 40	3·52	− 21 38·3	0·18	7·7
660	551	—	D. M. + 39°. 4114,	13 0	2·13	+ 40 1·3	0·18	5·4

No.		OBSERVATIONS.
641		h. 1470; 8·9, 10·0; ruddy yellow; contrasted green.—*E.'s obs.:* 1887, Dec. 7, 8·0; very orange red.
642	*Schj.'s notes*, .	"Cape obs.: ruby; 7·5. Arg., 20234; 7. Secchi; rossa."—*Addit. obs.:* A. G. C.; red.
643	"	"Pechüle; roth. (Briefl. Mittheil.)."—*Addit. obs.:* 1879, Sept. 17, 8·7; reddish: Oct. 5, 8·5; red (D.). 1876, Oct. 15, 10. 1886, June 24, 9½; deep red (Fr.). 1886, Nov. 18, 8·5; fine red; *var.?* 1889, Sept. 22, 8·5; very red (Es.).
644	"	"Cape obs.: very red; 8·5."
645	Secchi, . .	*Prodromo*, &c. 1876, No. 372; gialla rossa; 6·8.
646	*Schj.'s notes*, .	"Schönf. Cat.; röthlich. A. N., 1730; stark röthlich." See Gore's Var. Star Catalogue.
647	Webb, . . .	1882, Sept. 6, 9; pale ruby, with 10 blue near: Sept. 8, *comes*, blue, at 96°; 30″.
648	*Schj.'s notes*, .	"Hind; reddish. Schönf.; roth." See Gore's Var. Star Catalogue.
649	"	"Cape obs.: dark ruby; 10." Not seen by Webb or Birm. Several searches in 1871, '73, and '74.—*Addit. obs.:* 1875, July 28, 9·0; red (C.). 1879, Oct. 3, 9·5; red (D.).
650	Birmingham, .	1876, Aug., red; 9.—*E.'s obs.:* var. between 7·8–9·3. Wolsingham Observatory Circular, No. 6. A. N., 2746; 2764. A variable of the 19 Piscium type.
651	Pickering, .	No. 36 (A. N., 2376); very red. Pickering (private letter); 1886, Sept. 29, 10 mag. Suspected *var.* by Es. (Wolsingham Observatory Circular, No. 8), between 8·5–9·5. Probably a var. of the 19 Piscium type.
652	Pickering, .	No. 37 (A. N., 2376); colour, strong red. Pickering (private letter); 1886, Sept. 29, 9·4.—*E.'s obs:* several, 1886–87, 9·0; yellowish.
653	*Schj.'s notes*, .	"Schönf. Cat.; röthlich." See Gore's Var. Star Catalogue.
654	Pickering, .	No. 38 (A. N., 2376); red. Pickering (private letter); 1886, Sept. 29, 12 mag. Professor Pickering, in this letter, adds that there are two small stars, 12 to 12·5 mag., one p. $1^{s}{\cdot}7$ n. 1′·5; the second f. $5^{s}{\cdot}5$ on parallel. "No. 36 and 38 appeared noticeably red, but in last night's obs. (Sept. 29, 1886), No. 37 seemed at most, yellow. In 1880, it was described as nearly of the same colour with No. 36. It is possible that No. 38 was brighter then than now; for, owing to its faintness at present, it would hardly be expected to attract attention. There is, however, no record of its mag. in 1880. Possibly it may be worth while to watch it for variation." The places of No. 36, 37, 38, here given, are from the same letter.
655	Konkoly, . .	1883, Aug. 26, Sept. 1, gelblich roth; 7. A. G. C., 7½.
656	*Schj.'s notes*, .	"Schönf. Cat.; gelbroth." See Gore's Var. Star Catalogue.
657	Webb, . . .	C. O., 3rd Ed., p. 239, red; 9.—*Addit. obs.:* 1881, Oct. 15, 8; reddish white (Do.).—*E.'s obs.:* variable from 0·2 above, to 1·0 mag. below the companion (7·2; 2′·5 n.): Wolsingham Observatory Circular, No. 17. Variable, of the 19 Piscium type.
658	*Schj.'s notes*, .	"Schönf. Cat.; röthlich." See Gore's Var. Star Catalogue.
659	"	"Hist. Cél., p. 174; rouge; 7·5. Cape obs.: pure red—perhaps the finest of my ruby stars. Argel., 20363; 7. Secchi; rossa cupa; 7·5–8."—*B.'s obs.:* 1873, Sept. 2, red, not deep. 1876, July 14, red; 7·5.—*Webb's obs.:* 1873, Sept. 3, decided, but not very deep ruby; 6.—*Addit. obs.:* 1875, Aug. 5, 7·8; deep full red; Aug. 17, 7·5; deep red (C.). 1879, Sept. 19, 7·0; very red (D.). Secchi and Gore find variation. See Gore's Suspected Var. Stars.—*E.'s obs.:* 1882, Sept. 4, 7·3. 1883, Aug. 29, 7·0: Sept. 21, 7·1. Probably a var. of the 19 Piscium type.
660	Webb, . . .	(Private letter); orange.—*B.'s obs.:* 1876, Oct. 31, red orange; 5·4.—*Addit. obs.:* 1865, Sept. 22, very fine yellow; 7·0. 1876, Aug. 25, orange; 7·5. 1877, Nov. 30, pale orange ruby; 8·0 (W.). 1881, Oct. 15, yellow (Do.).—*E.'s obs.:* 1885, July 2, above 6·0; pale red: Oct. 1, 6·0; fine orange; *comes*, 11·0 mag., 110°; 20″: Nov. 30, 7·0; pale orange red; *comes*, 11·0 mag., 90°; 15″. 1886, July 17, 5·2 (estimated with comparison stars): Nov. 3, 6·0.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
660	551	—	D. M. + 39°. 4114,	xx.^{h} 13^m 0^s	+ 2^s·13	– 40° 1′·3	+ 0′·18	5·4
661	552	239	. . . .	13 21	3·07	+ 0 15·3	0·18	8·9
662	—	—	D. M. – 1°. 3954,	14 13	3·09	– 0 59·4	0·18	7·8
663	553	239*a*	U Cygni, . . .	16 12	1·86	+ 47 32·8	0·19	var.
664	554	—	D. M. + 36°. 4025,	17 13	2·25	+ 36 35·0	0·19	9·5
665	—	—	D. M. + 37°. 3903,	17 33	2·24	+ 37 11·3	0·19	9·4
666	—	—	D. M. + 39°. 4152,	17 40	2·14	+ 40 5·7	0·19	8·8
667	556	240	. . . .	19 11	3·07	+ 0 11·8	0·19	—
668	—	—	D. M. – 0°. 3997,	19 34	3·08	– 0 38·8	0·19	8·6
669	558	241	. . . .	20 27	2·89	+ 9 41·9	0·19	6·5
670	—	—	D. M. + 39°. 4172,	20 51	2·16	+ 39 47·5	0·19	7·5
671	559	242	L. 8451, ...	21 13	3·67	– 28 37·4	0·19	7¼
672	—	—	D. M. + 15°. 4172,	24 6	2·76	+ 15 53·9	0·20	8·3
673	—	—	D. M. + 39°. 4208,	24 51	2·18	+ 39 36·8	0·20	9·2
674	—	—	D. M. + 48°. 3133,	25 6	1·87	+ 48 33·3	0·20	6·8
675	561	243	. . . .	25 46	3·06	+ 0 25·8	0·20	—
676	562	—	ω^3 Cygni, . . .	27 54	1·85	+ 48 50·6	0·20	5·9
677	—	—	. . . .	29 58	2·51	+ 27 56·1	0·20	neb.
678	565	243*a*	. . . .	32 40	3·06	+ 0 37·9	0·21	8·3

No.	OBSERVATIONS.	
660	*continued*—	Gore (private letter); 1886, June 19, 6·2: Aug. 22, 28: Sept. 3, 8, 5·7. The star certainly seems var.
661	*Schj.'s notes*, .	"Bond, I., p. 71; orange red; 9·5. Ll., 38988; 8·5. Bessel, 269; 9."—*Dublin obs.:* Burton; 1876, deep red.—*Addit. obs.:* 1875, July 23, 9·0; red: Sept. 13, 9·0 (C.).
662	A. G. C., . .	7¾; crimson.
663	*Schj.'s notes*, .	"Birmingham; A. N., 1809, 1843; sehr roth; 8."—*B.'s obs.:* This star, which I found as a remarkable ruby star on 26th May, 1870, was subsequently made out by Mr. Knott to be variable; A. N., 1862. The Rev. T. W. Webb describes it in a letter, as showing "one of the loveliest hues in the sky." The contrast, with its blue neighbour (D. M., + 47°. 3078; 8·3), is very beautiful; and the latter star I believe to be *slightly* var. See Gore's Var. Star Catalogue. *E.'s obs.*, many; always very red, but companion not blue.
664	Webb, . . .	(Private letter); red; 8·5.—*B.'s obs.:* fine full red.—*E.'s obs.:* 1885, July 9, 9·7; very red. 1886, June 22, 9·0: Aug. 29, 8·7. 1887, April 14, 9·0; very red; var.?
665	Espin, . . .	No. 221. 1887, April 2, 8·5; very red; var.?
666	Espin, . . .	No. 114. In field with γ Cygni. 1885, July 8, 8·8; very red. 8 obs. in 1885, make it 8·8 to 9·0. 1886, June 16, 8·3: June 22, 8·1: June 26, 7·9. Since this time many obs. confirm its mag. at 8·0. (Comparison star, D. M. + 39°. 4157, 40^{s}·9 f. 0′·2 n. 8·3 mag.). Variable.
667	*Schj.'s notes*, .	"Bond; reddish; 10."—*Dublin obs.:* Burton; 1876, Aug. 15, not seen.—*Addit. obs.:* set for three times in 1875 by C., and once in 1879 by D., and not seen.
668	Webb, . . .	1877, Nov. 3, 8 mag.; orange, rather a ruby cast.
669	*Schj.'s notes*, .	"Lamont, z., 265; rubra; 8·5. Ll., 39304, '07, 08; 7, 6, und 6·5. Akad. Sternk.; 7·5. Birmingham (A. N., 1964); vermuthet, dass er veränderlich sei, und Argel. (A. N., 1977) ist zu demselben schluss gekommen."—*B.'s obs.:* 1872, July 14, 1873, July 21, not seen Sept. 24, orange; 6–6·5. 1874, Jan. 13, orange; 6·5: May 8, pale yellow; 7·5: June 15, pale orange; 5·5: Sept. 23, pale orange; 6: Nov. 6, light orange; 6: Nov. 29, orange; 6. 1875, May 15, orange; 6·5: July 25, orange; 6·5: Oct. 23, orange; 7: Nov. 10, orange; 6·5. 1876, April 13, fine yellow, orange cast; 6; twilight beginning: May 19, pale yellow; 6·8: June 25, pale red; 7; July 11, pale red; 7: July 17, pale reddish; 7: Aug. 10, 7·2. This star is certainly *var.*—*Dublin obs.:* Burton, 1876, July 17, very pale red; 7·5.—*Addit. obs.:* 1880, Aug. 27, scarcely a reddish tinge; 7·8: Nov. 20, good orange; 6–6·5. 1882, Nov. 13, pale red; 6·5–7 (Bm.). 1875, Aug. 18, 6·5; yellow (C.). 1879, Sept. 23, 7·0; orange: Oct. 5, yellow. (D.).
670	Webb, . . .	1876, Aug. 30, 8½; orange ruby.—*E.'s obs.:* 1885, July 2, 8·0; pale orange red, and so in subsequent obs., '86, '87, '88, '89.
671	*Schj.'s notes*, .	"Conn. des Temps, xv.; rouge; 8. Cape obs.: fine ruby; 8."—*Addit. obs.:* A. G. C., red.
672	Webb, . . .	1873, Sept. 12, ruby; 9·0; *comes*, 14 mag., n. p. 1875, Oct. 2, pale ruby; 8·5; two faint *comites*, n. p. Vogel (Spect. Beob.); 1880, Sept. 11, gelblich roth.—*E.'s obs.:* 1885, July 9, 8·5; red, with 8·0, blue, near.
673	Espin, . . .	No. 118. 1885, July 9, 7·9; very red; subsequently diminishing to 9·0, and showing slight irregularities in '86, '87, '88; probably a variable of the 19 Piscium type, but doubtful.
674	Lindemann, .	No. 35. 1873, Aug. 25, kupferroth: Sept. 1, gelbroth.—*E.'s obs.:* 1886, June 30, 7·0; red.
675	*Schj.'s notes*, .	"Bond; red; 10·0."—*Dublin obs.:* Copeland: 1875, Aug. 17, white, or yellowish; 9·4. Burton; 1876, Aug. 20, dull; no decided colour.
676	Schmidt, . .	(A. N., 1992); deep golden yellow. Smyth, DCCLIV.; pale red. Sadler; yellowish red.—*Addit. obs.:* Webb; 1850, Oct. 9, fine deep yellow. Lindemann; 1872, Oct. 16; gelb. 1873, Aug. 25, kupferroth: Sept. 1, gelbroth. Franks; 1884, Dec. 20, fine orange.—*E.'s obs.:* 1885, July 13, fine pale red.
677	Earl of Rosse,	Neb. Obs., p. 157 (note on G. C., 4591). 1871, Aug. 28, Cl., contains a red star.
678	*Schj.'s notes*, .	"Bond; reddish; 9."—*Addit. obs.:* 1875, July 25, 8·0; full yellow, or reddish: Aug. 5, 8·2; yellow. Aug. 17, 8·0; orange: Sept. 8, 8·0; full red (C.).

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
679	566	—	D. M. + 17°. 4370,	xx^h 32^m 54^s	+ 2^s·74	+ 17° 52′·7	+ 0″·21	7·0
680	—	—	D. M. + 68°. 1140,	36 0	0·48	+ 68 11·8	0·21	8·8
681	—	—	V Cygni, . . .	37 46	1·93	+ 47 44·9	0·21	var.
682	567	243c	S Delphini, . . .	38 1	2·76	+ 16 41·6	0·21	var.
683	568	243d	T Delphini, . . .	40 16	2·78	+ 15 59·9	0·21	var.
684	569	—	D. M. + 17°. 4401,	40 26	2·75	+ 17 41·5	0·21	6·8
685	—	—	D. M. − 3°. 5018,	41 20	3·12	− 2 53·3	0·22	6·8
686	—	—	D. M. + 55°. 2462,	41 31	1·56	+ 56 5·4	0·22	6·0
687	—	—	3 Aquarii, . . .	41 56	3·17	− 5 25·8	0·22	4·2
688	—	—	D. M. + 45°. 3271,	43 8	2·04	+ 45 38·9	0·22	8·8
689	—	—	D. M. − 1°. 4057,	43 38	3·09	− 0 57·9	0·22	6·8
690	—	—	D. M. + 22°. 4203,	43 58	2·66	+ 22 35·2	0·22	8·0
691	571	243e	T Aquarii, . . .	44 8	3·17	− 5 33·3	0·22	var.
692	—	—	D. M. + 45°. 3289,	45 3	2·05	+ 45 26·7	0·22	8·6
693	573	244	. . . .	52 4	2·79	+ 15 49·7	0·23	7·3
694	—	—	D. M. + 3°. 4466,	52 18	3·01	+ 3 45·5	0·23	6·5
695	—	—	D. M. + 30°. 4246,	52 24	2·49	+ 30 58·6	0·23	9·5
696	—	—	D. M. + 45°. 3349,	54 11	2·07	+ 46 2·7	0·23	8·1
697	—	—	. . . .	58 54	2·54	+ 29 27·7	0·23	--
698	574	244a	R Vulpeculæ, . .	59 29	2·66	+ 23 23·1	0·24	var.
699	—	—	D. M. − 17°. 6181,	xxi. 1 7	3·36	− 16 51·9	0·24	8·2
700	—	—	T Cephei, . . .	8 2	0·81	+ 68 2·8	0·24	var.
701	577	245	. . . .	8 16	3·07	+ 0 14·3	0·24	9·3
702	578	246	. . . .	9 54	3·12	− 3 0·0	0·25	8·7

No.	OBSERVATIONS.	
679	D'Arrest, . .	(A. N., 2009); gelbröthlich.—*Addit. obs.:* Vogel (Spect. Beob.); 1880, Sept. 11, gelblich roth, estimated 6·5. Dunér; rouge-jaune.
680	Espin, . . .	No. 260. 1887, Oct. 15, 20, 8·5; red.
681	Birmingham, .	Very red: discovered May 22, 1881. See Gore's Var. Star Catalogue.
682	*Schj.'s notes*, .	"Schönf. Cat.; gelbroth." See Gore's Var. Star Catalogue.
683	,,	"Schönf. Cat.; stark gelbroth." See Gore's Var. Star Catalogue.
684	D'Arrest, . .	(A. N., 2016); 1874, Sept. 10, auffallend röthlich; 8; *var.*—*Addit. obs.:* Vogel (Spect. Beob.); 1880, Sept. 11, röthlich gelb. Dunér; rouge-jaune.—*E.'s obs.:* red, and *var.* See Gore's Var. Star Catalogue.
685	Konkoly, . .	1883, Sept. 5, Oct. 28, 6·5; gelblich roth. Schönfeld; roth.
686	Birmingham, .	1879, Dec. 16; 1880, Nov. 20, red, not deep; 5·5. Dunér; rouge-jaune.
687	Dunér, . . .	Rouge-jaune. Franks; 1885, Sept. 6, fine orange. Cornish; orange. Konkoly; 1883, Aug. 1, 31, gelb; 4·5.—*E.'s obs.:* 1880, Aug. 28, fine orange.
688	Espin, . . .	No. 119. 1878, Jan. 10, 8·5; red. 1885, July 25, 8·0; fine red: Oct. 1, orange red; 9·0: Oct. 27, 8·5: Nov. 28, 8·8; very red. 1886, Nov. 2, 8·8; red. Safarik (A. N., 2402); roth; *var.*
689	Konkoly, . .	1883, Oct. 30, Nov. 1, 7; gelblich roth. Vogel (Spect. Beob.); 1881, Sept. 25, röthlich gelb. Dunér; jaune-roth.
690	Dunér, . .	Rouge-jaune.
691	*Schj.'s notes*, .	"Schönf. Cat.; röthlich." See Gore's Var. Star Catalogue.
692	Espin, . . .	No. 120. 1878, Jan. 10, 9·0; red. 1885, July 25, 8·5; reddish: Oct. 1, 8·5: pale orange red: Nov. 28, 9·0. 1886, Nov. 2, 8·5; pale red. Safarik (A. N., 2402); roth; *var.*
693	*Schj.'s notes*, .	"Lamont, z., 204: rubra; 8. Bessel, 1294; 8."—*B.'s obs.:* 1872, July 14, not seen. 1873, Sept. 15, 24, pale red: Oct. 6, pale red; 8. 1874, Nov. 29, slightly reddish; 8. 1875, Oct. 23; slightly red; 7·5–8.—*Webb's obs.:* 1873, Sept. 12, 13; 25; very pale ruby; 8.—*Dublin obs.:* Copeland; 1875, Aug. 17, red; 8: Sept. 18, full orange; 8 (*var.*)? Burton (dates not recorded); pale red, 6; pale red, 6–7; white, or very pale yellow, 6·5.—*Addit. obs.:* 1878, Sept. 25, 8·0; reddish (D.). 1884, Dec. 16, orange (Fr.).
694	Webb, . . .	1883, Oct. 20, 6·5; pale orange ruby. Vogel (Spect. Beob.); 1881, Sept. 25, gelb; estimated 7·0.—*E.'s obs.:* 1887, Dec. 7, 7·5; very pale red.
695	Webb, . . .	1877, Dec. 6, 9·0; very pale ruby.—*E.'s obs.:* 1887, Dec. 7, 8·8; reddish; near the great Cygnus Neb.
696	Espin, . . .	No. 123. 1885, Dec. 15, 8·0; very red: Dec. 25; 1886, Jan. 15, June 30, Aug. 20, 8·0; fine red.
697	Earl of Rosse,	(Neb. Obs., p. 160); note on G. C., 4632. 1873, Sept. 24, the 9 mag. n. p. is red.
698	*Schj.'s notes*, .	"Schönf. Cat.; gelbroth. See Gore's Var. Star Catalogue.
699	Holden, . .	No. 77. 1881, Sept. 9, 8·5; red.
700	Ceraski, . .	Var.; red. See Gore's Var. Star Catalogue.
701	*Schj.'s notes*, .	"Bond; red; 9·5."—*Dublin obs.:* Burton; 1876, tint not remarkable; perhaps yellow.—*Addit. obs.:* 1875, Aug. 5, 9·0; reddish, but too faint to be sure (C.). 1879, Sept. 13, 9·2: pale yellow (D.).
702	,,	"Schj., 8581; roth; 8·5." Ll., 41252; 8·5. Bessel, 158; 9.—*B.'s obs.:* 1873, Oct. 4, slightly red; 7·7. 1875 (date uncertain), slightly reddish; 8–8·5: Oct. 23, scarcely, if at all red; 8·5.—*Webb's obs.:* 1873, Sept. 3, 25, barely flushed; 8.—*Dublin obs.:* Burton; 1876, July 14, dull, scarcely red; 9.—*Addit. obs.:* 1875, Sept. 8, 8·0; full orange (C). 1879, July 26, 8·0: Sept. 23, 8·7; deep orange: Sept. 30, 8·8 (D.).

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
703	579	247	. . . .	xxi.^{h} 9^{m} 59^{s}	+ 1^{s}·53	+ 59° 38′·6	+ 0′·25	7·5
704	580	248	L. 8745, ...	14 18	5·53	− 70 12·1	0·25	6·8
705	582	248*b*	. . . .	18 16	2·29	+ 41 55·6	0·25	—
706	—	—	D. M. + 61°. 2134,	23 1	1·48	+ 62 5·8	0·26	8·8
707	584	249	. . . .	26 37	2·04	+ 51 5·3	0·26	—
708	585	—	D. M. + 45°. 3584,	29 10	2·23	+ 45 22·0	0·26	6·5
709	587	—	D. M. + 44°. 3877,	31 53	2·27	+ 44 53·0	0·27	6·7
710	588	250	S Cephei, . . .	36 35	− 0·65	+ 78 7·7	0·27	var.
711	589	249*a*	. . . .	37 23	+ 2·53	+ 35 0·5	0·27	6·2
712	590	—	Nova (1876), . .	37 23	2·36	+ 42 20·4	0·27	var.
713	592	251	. . . .	38 43	2·48	+ 37 30·8	0·27	7·8

No.		OBSERVATIONS.
703	*Schj.'s notes,* .	"Conn. des Temps, xv.; rouge; 8. Piazzi, 61; rubei coloris; 7. Argel., 21894; sehr roth; 8. Secchi; schwach roth; 8·5. Birmingham (M. N., xxxiv.); 6·5."—*B.'s obs.:* 1872, 1873, several obs.; orange red; 6·5. 1875, Oct. 23, red; 7. 1876, Jan. 21, 7–7·5: June 26, fine red; 7.5. *Variable* (?).—*Webb's obs.:* 1873, Nov. 15, red, not deep—*Dublin obs.:* Copeland; 1875, Sept. 28, very deep red; 9. Burton, 1875, Aug. 10, strong red; 8. 1876, Aug. 12, 20, 31, deep red; 7·6.—*Addit. obs.:* 1871, Dec. 6, 7·5, pale ruby (W.). 1879, Sept. 19, 7·3; orange: Oct 5, 7·5; deep orange (D.). 1880, April 9, 7·0; red. 1887, May 15, 7·0; very orange red; 6·5, blue p. (Es.).
704	"	"Cape obs.: red, inclining to orange; 6."—*Addit. obs.:* A. G. C., red. Stone; red.
705	"	"Lassel; M. N., xvii., p. 66; deep red."—*Dublin obs.:* Copeland; 1875, Sept. 8, full red; 9·2, 0′·5; s. f. is an orange 8. Burton; 1876, Aug. 31, strong red; 9·5.—*Addit. obs.:* 1875, Aug. 5, 9·3; red: Sept. 28, 9·2; deep red (C.). 1878, Sept. 25, 9·2; reddish (D.).
706	Espin, . . .	No. 128. 1885, Oct. 27, 8·7; very red, and same in several observations, 1885, '86, '87, 88.
707	*Schj.'s notes,* .	"h. 2124; ruddy star, 11 mag., in cluster."—*B.'s obs.:* 1873, May 3, may be reddish.—*Dublin obs.:* Burton, 1876, thought to be red, but not certain.—*Addit. obs.:* 1876, Sept. 8, 10·5; red? Sept. 28, 10·2: red? too faint (C.). Dunér (p. 91), says, "I have often examined the little cluster wherein this star is situated, but have never seen it."
708	Webb, . . .	(Private letter); pale orange; 7.—*Addit. obs.:* 1876, Sept. 9, 8·0; orange ruby; a splendid star. 1877, Nov. 23, 7·5; orange red (W.). 1885, Oct. 27, 7·5; very pale red (Es.).
709	Webb, . . .	(Private letter); fine red; 7.—*B.'s obs.:* Sept. 3, fine red; 6·8.—*Addit. obs.:* 1877, Nov. 27, orange red; 7·5 (W.). 1885, Jan. 7, orange (Fr.). 1885, Oct. 27, 7·0; very pale red (Es.).
710	*Schj.'s notes,* .	"Conn. des Temps, xv.; rouge. Arg., 22734; sehr roth. Schönf. Cat.; 1866, intensiv roth. *Dublin obs.:* Copeland; 1875, Sept. 20, very deep red; 7·8. See Gore's Var. Star Catalogue.
711	"	"D'Arrest; 1874, Juli, auffällig roth. Bessel, 889, 7."—*Addit. obs.:* 18[illegible], July 26, 6·0; red (D.). 1887, Sept. 18, 7·0; very red (Es.).

712 The new star discovered by Dr. Schmidt, director of the Athens Observatory, on November 24, 1876. The rise of this star to its greatest magnitude—the 3rd—must have been very rapid, as Dr. Schmidt shows by the dates of his observations of the constellation Cygnus between Nov. 1 and 20. Its colour, which, on the evening of its discovery, was a full deep yellow, remained unchanged up to Dec. 11, when it had fallen to 6·7 magnitude. It never during that period showed any decided mixture of red, as could be seen by comparison with 75 Cygni, whose vivid red yellow was very evident. The magnitudes from the date of its discovery to Dec. 15, when it was last visible to the naked eye, were as follows:—

Nov. 24, . . .	3·0	Dec. 1, . . .	5·2	Dec. 9, . . .	6·6
" 25, . . .	3·1	" 2, . . .	5·4	" 11, . . .	6·7
" 26, . . .	3·1	" 3, . . .	5·6	" 12, . . .	6·7
" 27, . . .	3·2	" 4, . . .	5·8	" 13, . . .	6·8
" 28, . . .	3·8	" 5, . . .	5·9	" 14, . . .	6·9
" 29, . . .	4·7	" 7, . . .	6·3	" 15, . . .	7·0
" 30, . . .	5·0	" 8, . . .	6·5	" —	—

On Nov. 24 its light made 75 Cygni invisible; on Dec. 15 the light of the latter made the other invisible. *Astr. Nachr.*, 2115. On January 2, 1877, Dr. Copeland, at Dunecht, found the star of a "decided *red* colour," and 7 magnitude. A. N., 2116. For an account of the spectrum of this star see the section on "Stars with bright lines in their Spectra."

No.		OBSERVATIONS.
713	*Schj.'s notes,* .	Bessel, 923; roth; 8. Argel., vi., p. 202; roth und feurroth. Lassell, M. N., xvii., p. 66."—*B.'s. obs.:* 1872 and '73; fine red: several obs. 1874, May 8, fine red; 7·5: June 15, splendid red; 7·8. 1875, May 15, July 27 and Nov. 26, splendid red; 8: Nov. 29, splendid red; 7·8. 1875, May 15, July 27, and Nov. 26, splendid red; 8. 1876, May 19, deep red; 8 at least.—*Webb's obs.:* 1871, Aug. 9, red, not deep. 1873, Oct. 24, very fine ruby; 8·5. 1874, Oct. 20, fine red; 8·5.—*Dublin obs.:* Copeland; 1876 May 19, brownish yellow. —*Addit. obs.:* 1878, Sept. 16, 9·5; probably underrated, very fine colour (W.). 1875, Sept. 10, 8·0; red: Sept. 28, 7·3; very deep red (C.). 1878, Sept. 18, 7·0; very red: Sept. 25, very deep red (D.). 1881, Aug. 9, fine red (H.). 1885, Jan. 7, orange vermilion (Fr.).

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
714	594	253	. . . .	xxi.^{h} 40^{m} 8^{s}	+ 1^{s}·83	+ 58° 16′·5	+ 0″·27	var.
715	—	—	. . . .	40 9	2·01	+ 54 6·8	0·27	neb.
716	595	255	. . . .	40 18	2·04	+ 53 11·9	0·27	—
717	—	—	47 Capricorni, . .	40 24	3·20	− 9 46·9	0·27	6·7
718	596	254	. . . .	40 50	3·11	− 2 43·3	0·27	6·8
719	597	256	. . . .	44 29	3·07	+ 0 27·1	0·28	9·5
720	598	257	. . . .	51 8	2·22	+ 49 58·6	0·28	9·1
721	—	—	D. M. + 23°. 4442,	54 45	2·77	+ 23 24·1	0·29	7·5
722	600	258	. . . .	59 0	2·71	+ 27 49·0	0·29	7·7
723	603	258*a*	T Pegasi, . . .	xxii. 3 32	2·93	+ 12 0·0	0·29	var.
724	—	—	D. M. − 5°. 5738,	8 7	3·13	− 4 59·8	0·29	7·3
725	605	259	. . . .	8 39	2·12	+ 56 43·6	0·30	neb.
726	609	261	. . . .	11 57	3·02	+ 4 35·7	0·30	7·8
727	—	—	π′ Gruis, . . .	16 1	3·70	− 46 30·1	0·30	6·7
728	610	262	. . . .	18 59	2·24	+ 55 24·4	0·30	7·2
729	—	—	. . . .	20 45	2·20	+ 57 16·7	0·30	neb.
730	614	262*b*	. . . .	28 52	3·06	+ 0 47·6	0·31	—

No.	OBSERVATIONS.	
714	*Schj.'s notes*, .	"Herschel's garnet star."—*B.'s obs.:* always a most beautiful object; orange; truly described as the reddest naked-eye star in the Northern heavens.—*Webb's obs.:* orange. See Gore's Var. Star Catalogue.
715	Earl of Rosse,	(Neb. Obs., p. 162); note on G. C., 4700. 1871, Aug. 25, cluster of small stars, with a red star at s. f. corner.
716	*Schj.'s notes*, .	"h. 2130; ruby; 9·5. Rosse, Phil. Trans., 1861; red."—*Addit. obs.:* 1878, Oct. 6, 9·0; orange. 1879, Sept. 13, 9·2; red: Oct. 15, 9·5 (D.).
717	Konkoly, . .	1883, Aug. 5, 6, gelblich roth; 6. Espin, No. 185; 1886, Nov. 17, orange red; 6·0.
718	*Schj.'s notes*, .	"Hist. Cél., p. 183; rouge; 6·5. Bessel, 942; 7·5. Secchi; rossa; 5–6."—*B.'s obs.:* 1873, June 22, not seen as a red star: July 21, pale orange; 6·5. 1874, Sept. 19, pale orange; 6·5. 1875, July 21, pale red; 8 at most: July 31, pale red; 6·5–7. It seems a quick change from July 21 to 31; but I give the magnitudes as I observed them. 1876, June 25, pale reddish; 7·5: July 17, pale red; 6. *Variable* (?).—*Webb's obs.:* 1873, Sept. 3, pale ruby; 6·5.—*Addit. obs.:* 1878, Sept. 30, 6·5; fine red. 1878, Oct. 1, decidedly red (C.). 1881, Aug. 9, red yellow, 1883·66; 6·7; very red (H.). 1884 Aug. 28, 7¾; deep red orange: Sept. 13, 7·7; red orange: Nov. 9, 7·8; red orange. 1885, Sept. 12, 7·5 (Gemmill). 1884, Nov. 3, 6·3; orange red (Fr.). 1886, Nov. 17, 7·5; very orange red(Es.).
719	„	"Bond, I., p. 99, red; 10."—*Dublin obs.:* Burton; 1876, Aug. 16, no decided colour visible. —*Addit. obs.:* 1875, Aug. 19, Sept. 10, 9·5; not very red: Sept. 28, 9·2; full yellow.
720	„	"Cape obs.: intense fiery red; 9."—*B.'s obs.:* 1873, April 25, decided, but not deep, red; 9·5–10. Preceded by a little double. 1874, Nov. 25, fine crimson; 9·5: Nov. 29, fine red; 10. 1875, July 31 and Nov. 21, not seen. 1876, July 17, good red; 10.—*Webb's obs.:* 1873, Nov. 15, very pale red; 9.—*Dublin obs.:* Burton; 1876, Aug. 16, deep red; 9·6.—*Addit. obs.:* 1875, Aug. 19, 9·0; deep red: Sept. 10, 9·0, very deep red: Sept. 28, 8·8; red (C.). 1878, Oct. 1, 9·0; red. 1879, Sept. 13, 8·8; reddish (D.).
721	Σ. 2850, ?. .	7·2; rubro-aurea.—*E.'s obs.:* 1887, Dec. 7, 7·5; red.
722	*Schj.'s notes*, .	"Cape obs.: ruddy orange; 8. D'Arrest; 1874, July, auffällig roth; hellbraun; 8."—*B.'s obs.:* 1873, Sept. 20, light red; 8. 1874, Nov. 25, 29, faint red; 6·5: Dec. 2, good red; 7, or rather less. 1876, July 17, reddish; 7·5–8. *Variable* (?).—*Addit. obs.:* 1875, Aug. 19, 8·0; orange: Sept. 10, 8·0; full orange: Sept. 20, 7·9; deep orange (C.). 1879, Oct. 5, 7·5; orange (D.).
723	„	"Schönf. Cat.; röthlich." See Gore's Var. Star Catalogue.
724	Konkoly, . .	1883, Oct. 2, gelblich roth; 7.
725	*Schj.'s notes*, .	"h. 2154; a ruby star; 10."—*B.'s obs.:* 1873, March 19, a star, perhaps reddish in neb.—*Addit. obs.:* Earl of Rosse (Neb. Obs., p. 164); 1854, Oct. 17, one of the brighter stars is of a red colour. 1885, Aug. 19, ruddy.—*E.'s obs.:* 1887, Dec. 4, 9·5; red.
726	„	"Lamont, z., 262; rubra; 8. Ll., 43501, '02; 8. Bessel, 198; 8·5."—*B.'s obs.:* 1873, Sept. 2, faint yellow; 8: Sept. 17, faint reddish; 8. 1874, Nov. 25, reddish; 7.—*Webb's obs.:* 1873, Dec. 12, pale ruby; 7·8.—*Addit. obs:* 1875, Aug. 19, 8·0; deep yellow: Sept. 12, 7·6; deep orange: Sept. 20, 7·8: full orange (C.). 1878, Sept. 18, 7·8; very red (D.). 1887, Nov. 15, 8·2; orange red (Es.).
727	Thome, . .	(Private letter) very red.
728	*Schj.'s notes*, .	"Argel., 23986; sehr roth; 6·5."—*B.'s obs.:* 1873, March 19, good orange; 6·5.—*Addit. obs.:* 1875, Sept. 8, 8·0; red: Sept. 12, 8·0; fine red: Sept. 20, 7·5; red (C.). 1878, Sept. 18, 6·7; decidedly red: Sept. 30, 7·0; very red (Do.). 1885, Nov. 16, 7·0; pale orange red. 1887, Dec. 4, 6·8; pale orange red (Es.).
729	Earl of Rosse,	(Neb. Obs., p. 165); G. C., 4791; 1871, Sept. 6, an intensely red star, the brighter of a double, precedes by 2 to 3 min.
730	*Schj.'s notes*, .	"Bond; lilac red; 11·0."—*Dublin obs.:* Burton; 1875, Sept. 20, certainly not very red.—*Addit obs.:* 1875, Aug. 19, 10·5: Sept. 28, 9·3; full red (C.). 1878, Sept. 25, 10·0; no colour seen, but very faint: Sept. 30, 10·5; difficult (D.). 1887, Nov. 15, no red star seen (Es.).

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
731	—	—	D. M. + 57°. 2568,	xxii.^{h} 32^m 16^s	+ 2^s·28	+ 57° 51′·5	+ 0′·31	7·3
732	617	262*c*	*β* Gruis, . . .	36 6	3·60	− 47 27·6	0·31	2·2
733	—	—	D. M. − 5°. 5843,	36 22	3·12	− 5 39·9	0·31	6·7
734	619	262*d*	. . . .	42 29	3·06	+ 0 45·6	0·31	8·5
735	—	—	D. M. + 54°. 2865,	44 12	2·48	+ 54 32·8	0·32	8·5
736	—	—	O. A. 22489, . .	49 17	3·31	− 30 11·7	0·32	8
737	—	—	D. M + 35°. 4917,	50 37	2·78	+ 35 45·9	0·32	6·0
738	623	262*e*	S Aquarii, . . .	51 13	3·23	− 20 55·8	0·32	var.
739	625	263	. . . .	54 8	3·26	− 25 45·1	0·32	6·1
740	626	264	. . . .	55 39	3·07	+ 0 29·7	0·32	8·5
741	626	265	R. Pegasi, . . .	xxiii. 1 7	3·01	+ 9 57·0	0·32	var.
742	631	—	. . . .	8 2	3·15	− 13 59·6	0·33	6·8
743	637	268	. . . .	14 45	2·96	+ 22 29·4	0·33	6·3
744	638	268*a*	S Pegasi,[1] . . .	14 59	− 3·03	+ 8 19·0	0·33	var.
745	—	—	D. M. − 14°. 6453,	15 30	+ 3·12	− 13 52·4	0·33	7·3
746	—	—	D. M. + 58°. 2586,	18 56	2·63	+ 58 34·6	0·33	9·0
747	639	269	. . . .	19 22	2·65	+ 60 59·0	0·33	neb.
748	640	270	. . . .	23 54	3·07	+ 0 29·2	0·33	9·4
749	641	271	. . . .	25 3	3·07	+ 0 16·3	0·33	7·7
750	642	272	. . . .	26 59	2·99	+ 23 14·3	0·33	6·8
751	643	272*a*	71 Pegasi, . . .	27 37	2·99	+ 21 53·5	0·33	6·0
752	—	—	D. M. + 7°. 5059,	29 51	3·05	+ 7 55·0	0·33	6·5

No.		OBSERVATIONS.
731	Birmingham, .	1879, Jan. 22, good red; 8 mag. Ball (private letter to Bm.); 1880, Jan. 21, certainly red; not 7 mag. Espin, No. 137; 1885, Oct. 24, pale orange red; var. 7·2–8·0. (See M. N., xlvi., p. 297).
732	*Schj.'s notes*, .	"Engelmann, A. N., 1828, röthlich."—*Addit. obs.:* 1882, Dec. 7, rouge (Pechüle).
733	Konkoly, . .	1883, Sept. 1, Oct. 6, gelblich roth; 6·5.
734	*Schj.'s notes*, .	"Bond, ii., p. 63; reddish orange; 9."—*Addit. obs.:* 1875, Aug. 19, 9·0: deep red: Sept. 20, 9·2; orange: Sept. 28, 8·0; orange (C.).
735	Espin, . . .	No. 267. 1887, Oct. 20, 8·5; red: Dec. 4, red, not deep: Dec. 7, very red.
736	A. G. C., . .	Crimson.
737	h. 975, . .	6·0, 9·0; white, red. Earl of Rosse (Neb. Obs., p. 169); note on G. C., 4868. 1871, Aug. 25, a double star p.: the p. component is very red.
738	*Schj.'s notes*, .	"Schönf. Cat.; goldgelb bis roth."
739	,,	"Hist. Cél., p. 181; rouge; 6. Argel., 22540; 7."—*B.'s obs.:* twinkles reddish. Several obs.—*Addit. obs.:* 1875, Aug. 19, 6·0: Sept. 12, 6·5; red: Sept. 28, 6·0; yellow (C.).
740	,,	"Bond; red; 9. Schj., 9450; 8·7."—*Addit. obs.:* 1875, Sept. 11, 8·5; full red: Sept. 13, 8·6; red: Dec. 17, 9·0; red (C.). 1878, Oct. 17, 8·8; reddish (D.).
741	,,	"Hind; red. "Schönf. Cat.; roth." See Gore's Var. Star Catalogue.
742	Burnham, . .	(M. N., xxxvi., No. 7); large star reddish; 7.—*Addit. obs.:* 1878, Oct. 17, 7·5; orange: Oct. 28, 8·0; reddish. 1879, Dec. 4, 7·3; orange (D.).
743	*Schj.'s notes*, .	"Lamont, z., 221; rubra; 8·5. Bessel, 262: 7."—*B.'s obs.:* 1873, Sept. 2 and Sept. 17, palest yellow; 7·5. 1874, Nov. 6, pale orange; 5: Nov. 25 and 29, only reddish; 7: Dec. 13, orange; 6·5–7: Dec. 26, pale orange; 7. 1875, Jan. 28, orange; 7: Nov. 21, pale red; *at least* 7. *Variable* (?).—*Webb's obs.:* 1873, Dec. 12, very pale orange red; 8. —*Dublin obs.:* Burton; 1876, Sept. 26, not seen.—*Addit. obs.:* 1875, Sept. 13, 6·8; deep yellow: Sept. 20, 6·5; deep yellow (C.). 1878, Sept. 23, 6·5; reddish: Oct. 21, 6·5; orange (D.). 1879, Oct. 27, 5·5; white, perhaps slightly ruddy. 1880, Sept. 10, 6·7; reddish (Do.). 1880, Sept. 8, 8·0: scarcely, if at all tinged (Bm.). 1887, Nov. 15, orange (Es.).
744	,,	"Schönf. Cat.; gelblich roth." See Gore's Var. Star Catalogue.
745	Konkoly, . .	1883, Sept. 3, 5; gelblich roth; 7·5.
746	Espin, . . .	No. 270. 1887, Oct. 20, 8·6; very red.
747	*Schj.'s notes*, .	"h. 2238; ruddy; 9, in *p.* part. Argel., 2557; 8·5."—*B.'s obs.:* a reddish 8·5–9 on border.—*Dublin obs.:* Copeland; 1875, Aug. 19, deep red; 8·8; the lucida of a Cl.—*Addit. obs.:* 1875, Sept. 20, 8·9; full red (C.). 1878, Oct. 28, 8·3; reddish. 1879, Oct. 25, 8·5; yellow (D.).
748	,,	"Bond, i., p. 105; red; 10·5."—*Dublin obs.:* Burton; 1876, Oct. 20, deep red; 9·5. A nebulous 8·8 *f.* $3^{s}\cdot8$, *n.* $1'\cdot5$.—*Addit. obs.:* 1875, Sept. 11, 9·6: Sept. 28, 9·6; red (C.). 1879, Oct. 15, 10 ± through clouds: Nov. 13, 9·6: Dec. 8, 9·2; red (D.).
749	,,	"Bond, i., p. 187; red; 8. Ll., 46022; 8. Schj., 9691; 8."—*Addit. obs.:* 1875, Sept. 10, 7·8; full yellow: Dec. 17, 8·8; very deep red (C.). 1878, Sept. 19, 8·0: Oct. 6, 7·5; reddish: Oct. 27, 7·8. 1879, Dec. 4, 7·5; yellow (D.).
750	,,	"Lamont, z., 223; rubra; 8. Ll., 46112, '13; 7. Bessel 535; 7. D'Arrest; röthlich."—*B.'s obs.:* 1873, July 21, Sept. 17, pale yellow; 7·5.—*Addit. obs:* 1875, Sept. 12, 7·0; full orange: Sept. 20, 7·2; full orange (C.) 1879, Sept. 17, yellow (D.). 1880, Sept. 10, 6·2; pale red (Do.).
751	,,	"D'Arrest (Juli, 1877); röthlich."—*Addit. obs.:* 1875, Sept. 13, 6·5; full orange: Sept. 28, orange (C.). 1878, Sept. 20, 6·0: orange (D.). 1880, Sept. 10, 5·5; reddish yellow (Do.).
752	Vogel, . . .	(Spect. Beob.); 1880, Sept. 28, gelblich roth.

No.	No. in Birmingham.	No. in Schj.	Star's Name.	Right Ascension, 1890.	Annual Precession in R. A.	Declination, 1890.	Annual Precession in Declin.	Magnitude.
753	645	—	77 Pegasi, . . .	xxiii.^{h} 37^m 48^s	+ 3^s·05	+ 9° 43′·0	+ 0′·33	5·0
754	646	272*b*	R Aquarii, . . .	38 8	3·11	− 15 53·6	0·33	var.
755	647	—	78 Pegasi, . . .	38 30	3·01	+ 28 46·4	0·33	5·2
756	648	273	19 Piscium, . .	40 46	3·07	+ 2 52·6	0·33	6·2
757	649	274	. . . .	43 32	2·97	+ 44 34·6	0·33	9·5
758	—	—	φ Pegasi, . . .	46 54	3·05	+ 18 30·6	0·33	5·0
759	650	275	. . . .	46 54	3·07	+ 0 27·7	0·33	9·2
760	653	—	D. M. + 21°. 4999,	51 7	3·05	+ 22 2·2	0·33	6·0
761	656	278	R Cassiopeiæ, . .	52 49	3·01	+ 50 46·5	0·33	var.
762	—	—	. . . .	53 27	3·00	+ 62 16·3	0·33	—
763	657	279	. . . .	54 56	3·07	+ 0 27·2	0·33	8·8
764	658	280	. . . .	55 39	3·02	+ 59 44·6	0·33	7·8
765	—	—	D. M. + 42°. 4824,	58 43	3·06	+ 42 59·6	0·33	8·6
766	—	—	. . . .	59 4	3·05	+ 68 3·7	0·33	neb.

No.	OBSERVATIONS.	
753	Birmingham,	1876, Dec. 14, red; 6. Dunér; rouge-jaune.
754	*Schj.'s notes*, .	"Schönf. Cat.; sehr roth." See Gore's Var. Star Catalogue.
755	Birmingham,	1876, Oct. 23, red; pale, but certain.—*Addit. obs.:* 1880, Sept. 10, pale yellow, or perhaps reddish; an 8 mag. s. seems redder (Do.).
756	*Schj.'s notes*, .	"T. Mayer, Piazzi, &c.; subrubei coloris. Lamont, X. (v.), p. 57; rubra."—*B.'s obs.:* 1873, Sept. 17, fine red orange; 6. 1876, Sept. 16, red orange; 6.—*Addit. obs.:* E.'s obs. variable and typical star of this new class of variables, whose characteristics are colour, red; spectrum, IV. type; variation, 1·0 mag., sometimes more, sometimes less. Period, irregular, and liable to rapid increases of light. See Wolsingham Observatory Circular, No. 18. Also Gore's Var. Star Catalogue.
757	„	"Cape obs.: ruby; 10."—*B.'s obs.:* 1873, Sept., not seen as a red star.—*Webb's obs.:* not seen.—*Addit. obs.:* 1875, Sept. 20, 9·1; deep red (C.). 1878, Oct. 16, 9·2; orange: Oct. 24, 8·6; Oct. 25, 8·8; red: Oct 31, 9·5. 1879, Nov. 13, 9·2; sky hazy (D.).
758	Vogel, . . .	(Spect. Beob.); 1881, Nov. 19, gelblich roth. Fr.; pale orange. Dunér; jaune-rouge.
759	*Schj.'s notes*, .	"Bond, red; 10. Schj., 9888, '89; 9 und 8·7."—*Addit. obs.:* 1875, Sept. 11, 9·4: Sept. 13, 9·0; reddish: Dec. 17, 9·0; not red (C.). 1878, Oct. 17, 9·2; pale orange (D.).
760	Webb, . . .	(Private letter, Oct., 1876); red, pale but certain.—*B.'s obs.:* 1876, Oct. 23, pale red.—*Addit. obs.:* 1880, Oct. 23, pale red; 6·5; small blue *comes*, 8° (Bm.). 1880, Sept. 10, 6; pale red (Do.).
761	*Schj.'s notes*, .	"Pogson, Radcl. Obs., XV., p. 294; vividly red. Auwers, A. N., 1239; hellroth. Schönf. Cat.; ausgezeichnet roth. Argel., VI., p. 257; sehr roth."—*B.'s obs.:* 1873, April 18, good orange red; 7.—*Dublin obs.:* Copeland; 1875, Sept. 11, magnificent deep orange; 7·8: Dec. 24, deep red; 8·9. A blue *comes* 20″ distant. See Gore's Var. Star Catalogue.
762	Pickering, .	No. 39. (A. N., 2376); red.
763	*Schj.'s notes*, .	"Bond, I.., p. 17; rose colour; 10. Bessel, 1090; 9."—*Addit. obs.:* 1875, Sept. 10, 8·8; yellow: Sept. 12, 9·5; (hazy) (C.).
764	„	"Argel., 26287; roth; 6. Secchi; rossa."—*B.'s obs.:* 1873, April 18, a good red; 7·5; the blue star near it; 9 (like U Cygni and neighbour). 1874, Jan. 15, fine red; 8·3 (the blue; 9·3): Feb. 17, good red; 7 (the blue; 9): March 12, red; 7·8 (the blue; 9): April 10, fine red; 7·5–8 (the blue; 9); May 7, fine red; 8 (the blue; 9·5): May 23, fine red; 8 (the blue; 10). 1875, May 15, fine red; 8 (the blue; 9): July 25, fine ruby; 7·5 (the blue; 9). 1876, Jan. 31, red, not so deep as formerly; 8·5–9: March 30, 8·5 (the blue; 9·5): April 14, fine red; 7–7·5 (the blue; 8): April 30, fine red; 7·5 (the blue; 8·3): May 19, fine red; seems recovering its colour, and now deeper than U Cygni; 8 (the blue; 9): June 25, red; 8·0 (the blue; 9·0): July 2, red; 7·8 (the blue; 9·0): July 6, red; 8·0 (the blue; 9·0): July 11, good red; 8·0 (the blue; 9·0): July 14, red: 8·1 (the blue; 9·0); July 17, getting paler; 8·1 (the blue; 9·0): July 26, fine red; 8·0 (the blue; 8·8): July 29, fine red; 8·1 (the blue; 9·0): Aug. 10, beautiful red; 8·2 (the blue; 9·0): Aug. 16, 8·4 (the blue; 9·0): Sept. 16, paler than usual; 7·8 (the blue: 9·0): Sept. 26, fine deep orange red; 7·0 (the blue; 9·0): Oct. 20, fine red (colour of U Cygni); 7·5 (the blue; 9·0): Dec. 24, fine red; 7·5 (the blue; 9·0). 1877, Feb. 26, fine red; 8·3 (the blue; 9): March 7, good red (the blue; 9·0). This star is certainly variable, as Secchi also has remarked.—*Webb's obs.:* 1874, Jan. 10, a very fine ruby; 9·7 (the blue star; 10): Jan. 12; 9 (the blue star; 10).—*Addit. obs.:* 1877, Dec. 18, intense and beautiful pure red; 8·5 (W.). 1878, Sept. 20, 7·5; very red: Sept. 25, 7·8; red: Oct 21, 7·2 (D.). 1881, Aug. 26, good red; 7·8; blue; 8·2 (H.). 1881, Oct. 15, 8; red (Do.). 1885, Dec. 4, 8·3 OR, 9·0 BB: Dec. 15, 80 ORR, 9·0 B. 1886, June 27, 7·2 R, 9·0 B: Nov. 2, 7·7 R, 9·0 B: Nov. 7, 7·5 R, 9·0 B. Nov. 17, 7·7 R, 9·0 B. A var., probably, of the 19 Piscium type. My obs. show no var. in the 9·0 mag. (Es.).
765	Espin, . . .	No. 272. 1887, Sept. 19, 8·3; red.
766	Earl of Rosse,	(Neb. Obs., p. 178); note on G. C., 5051. 1850, Oct. 11, not found. A red star, perhaps 12 mag., at this set, nearly same R. A. (But see Dreyer's note, Mem. R. A. S., vol. XLIX., Part i., p. 225, as to possible error of place.)

PART II.

SPECTROSCOPIC OBSERVATIONS OF STARS IN THE CATALOGUE.

Secchi divides the star-spectra into four types, to the first of which belong the white and the blue stars, such as Sirius, α Lyræ, α Aquilæ, and many others.

The second type has fine lines similar to our sun, and is represented by bright yellow stars of the first and second magnitudes. Among them are Arcturus and Pollux. There are cases, however, where this type seems to merge either into the third, or, more rarely, into the first.

The third type is found in the deep yellow, or red stars; and its chief representatives are α Orionis, α Scorpii, α Herculis, β Pegasi, ρ Persei, &c. In this type the principal lines given by the various stars are evidently in the same position; but there are notable diversities in the breadth of the zones, and in the shadings, which, in some cases, at first sight, give the idea of complete dissimilarity. This, however, is found to be only apparent; for, on closer examination, the spectra are seen to be fundamentally identical. The type is distinguished by bright, broad zones, about six or seven in number, separated by black lines, and semi-obscure, or nebulous intervals. Secchi takes α Herculis as the type star of this category, and describes the extraordinary *stereoscopic* effect of its bright zones, caused by the darkening toward the sides, and lights and shades such as serve a painter for representing solid columns. He remarks, however, that α Orionis and Antares, though of the same type as α Herculis, do not show these columns, on account of the greater separation and unequal distribution of the dark lines. Even very small Red Stars, such as ρ Persei, and π Aurigæ, show very fine columnar spectra.

In the Red Stars, Secchi has found a fourth type, with three principal zones—a very bright one in the green; a faint one in the blue; and a pretty bright one in the red, which is subdivided into minor zones. The fourth type differs notably from the third, not only in the division of the zones, which are twice as broad in the former as in the latter, but also in the positions of greatest and least brightness. Thus, while the light of the zones in the fourth type increases from the side of the red towards the violet, this disposition is reversed in the third. If, in fact, the third type may be represented as a series of columns, the fourth may be described as a system of cavities, or grooves, the light in both cases being supposed to fall in the same direction.*

Brilliant lines, like those of metals, are not wanting in stars of the fourth type; and it is remarkable that they appear at the brightest extremity of the coloured zones. The spectra of those stars are more gaseous than those of the others, and are specially indicative of carbon.

Dr. Vogel denies the gaseous character of these spectra, and disputes the grounds for forming Secchi's fourth type.† He affirms that, although the great breadth of the dark bands, in comparison with the luminous parts, might suggest the idea of a spectrum of only bright lines of a certain refrangibility, still, by careful study with powers of sufficient dispersion, and by comparisons with the spectra of known substances, it will be seen that the apparent discontinuity is only the effect of broad absorption bands referrible to an atmosphere surrounding a source of light with every degree of refrangibility. D'Arrest adopts Secchi's classification.

In reading Secchi's memoirs, one is struck by a change in the numerical arrangement of his types. For instance, in his *Memoria* I., p. 25, he describes the spectrum of α Herculis as columnar (*colonnato luminoso*), and characteristic of type II.; while, according to his second memoir, p. 9, it must be referred, not to the second type, but to the *third*, as "*un sistema di colonne.*" It is evident that he has altered the sequence, putting the solar type into the second place, and the columnar into the third; and this is the plan that is now generally adopted by spectroscopists.

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* *Sugli Spettri*, &c., *Memoria* II., p. 9.

† *Astr. Nachr.*, No. 2000.

Secchi said of the third type, before he discovered the fourth, that, though not the least important, it was the most uncommon, while so strikingly distinguished from the other two by the great nebulous lacunæ that divide the spectrum into zones.* It was found by D'Arrest in only 80 stars among 11,000 that he examined; and the fourth is so uncommon that we cannot expect to find it represented by more than one star in a thousand.†

According to Secchi, all the stars of the zone type tend strongly to a red colour; and it can be safely held that every Red Star gives a zone spectrum.‡ D'Arrest says that, although no white or blue star has been found with an absorption spectrum, on the other hand, many of the yellow and reddish yellow stars give, like the colourless stars, continuous spectra;§ but, in the *Astr. Nachrichten*, No. 2044, he says that, although hitherto the occurrence of strongly-marked absorption spectra was thought to be confined to the Red Stars, while types III. and IV. seemed to be equally represented by about twenty examples of each, it is now well ascertained that striking specimens of the third type are pretty numerous, and are often enough found in *absolutely colourless* stars—a statement that badly agrees with his previous assertion, that no blue or *white* star was to be found with an absorption spectrum. I think it right here to give D'Arrest's own words in the original. In the *Astr. Nachr.*, No. 2016, col. 369, he says:—"*Noch ist kein entschieden weisser oder bläulicher Stern mit scharf gezeichnetem Absorptionsspectrum aufgefunden worden;* dagegen giebt es am Himmel auch viele auffällig gelbliche und gelbröthliche Sterne, mit uniformen, gleichgültigen Spectren, ebenso wie bei den farblosen Sternen;" and in No. 2044, after remarking that he has nothing to alter in what he said in the previous numbers, he thus proceeds:—"während man bisher das Vorkommen von stark markirten Absorptionsspectren auf die rothen Sterne eingeschränkt geglaubt hat, und dabei den III. und IV. Typus für gleich zahlreich repräsentirt hielt—etwa zwanzig von jeder Art—steht es gegenwärtig fest, dass der *dritte* Typus in vorzüzlich ausgezeichneten Exemplaren ziemlich haüfig, und oft genug auch bei *absolut ungefärbten Sternen* angetroffen wird."

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* *Memoria* I., p. 42, where, however, it is called the second type.

† *Astr. Nachr.*, No. 2032.

‡ *Memoria* I., p. 43.

§ *Astr. Nachr.*, No. 2016.

It appears to Secchi that each of the several types shows a tendency to pervade a certain part of the heavens.* Thus, in the constellations Lyra, Ursa Major, Taurus, and, singularly, in the groups of the Pleiades and the Hyades, the type of *a* Lyræ predominates; while in Cetus, Cepheus, Draco, Eridanus, &c., the solar type prevails. The great constellation of Orion is distinguished by stars of the first type, showing modifications in the character of the lines, and in a predominence of the green, and a scantiness of the red. All this group, with its exaggerated development of the green, appears to participate in the nature of the great Orion nebula. D'Arrest, on the contrary, maintains that "general distinctions in the spectra in certain directions in space do not at all exist, or, at least, are not discerned. In the assertion, for example, that in the spectra of the small stars of Orion red and yellow are totally wanting, not a word is correct."† Here I may remark that Secchi does not assume any such total absence of any colour, but remarks a scantiness ("*scarsezza*") of the red in comparison with the marked development of the green;‡ and, after doing credit to Huggins for his capital discovery of monochromatic spectra among the nebulæ, he shows by his own observations that the light of the Orion nebula is in the bluish-green part of the spectrum.§ With respect to D'Arrest's denial of the preponderance of certain types of spectra in certain parts of the heavens, I may here refer to my previous remark that, so far at least as regards telescopic colours, I have found a distinguished prevalence of red and orange stars in what I have ventured to call "The Red Region;" and this fact cannot fail to impress me with the conviction that Secchi's views may be here substantially correct.

Writing in 1868, Secchi observes that, although according to the nature of spectra the obscure lacunæ in a zone spectrum may be considered to consist of aggregated lines, still no separation of them had been effected; and so the fact remained unproved.‖ D'Arrest, however, in 1875, announced his success in decomposing the dark bands of the large stars of the third type into plainly separated lines ("*deutlich gesonderten Linien*"). In these groups the lines increase in darkness and definition toward the *violet* side of the spectrum; and this causes the band to appear sharply edged on one side, and ill-defined on the other. The stars of the fourth type were too small to admit of observations like this; but it may be analogically assumed that their bands are similarly formed of distinct, separate lines, increasing in darkness towards the *red*, contrary to the former.*

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* *Memoria* I., p. 38.

† *Astr. Nachr.*, No. 2044.

‡ *Memoria* I., pp. 33, 34.

§ *Memoria* I., p. 39.

‖ *Memoria* I., p. 42.

One of the most striking examples of the disagreements among spectroscopic observers is found in the descriptions of the star No. 364 in the Catalogue (Schj. 152) by Secchi and Huggins. Secchi described the spectrum as composed of three bright and broad zones—one in the yellow, one in the green, and one in the blue. Huggins distinguishes the red as comparatively the freest from dark lines, and finds its brightness to accord with the red colour of the star. The spectrum showed to Secchi carbon, and no sodium—to Huggins sodium, and no carbon. Conclusions so opposite as these could scarcely be referred to a variability of the spectrum, a phenomenon that might account for minor discrepancies in many cases, as has been suggested by Secchi.† There need be but a passing allusion to the dispute between those eminent men regarding the use of the spectroscope as an indicator of the motions of the stars.

I have referred to differences found in the writings of spectroscopists chiefly for the purpose of showing how far we must as yet consider their science from a state that would demand unswerving assent to their deductions, and how cautious we must be in accepting as proved the several discoveries believed to be made regarding the constitution of the heavenly bodies. Exactness of observation, difficult in all astronomical work, seems specially so in spectroscopic researches; and to the ordinary errors of mechanical, physiological, and psychical origin must be added the uncertainties arising from the physical state, depending chiefly on temperature, of the object examined. The attempt to find out the composition of the stars by means of their spectroscopic features involves, indeed, a labour more difficult, and a result less reliable than, perhaps, is generally conceived.‡ Their atmospheres are complicated; and we see that in our own atmosphere there are substances, powerfully absorptive of the sun's light, which we are not as yet able to identify. What an instrument can do in modifying a spectrum may be understood from Secchi's account of his observations of 132 Schj., which showed a well-marked fourth type with a cylindrical lens, and a third type with a spherical; and that different spectra are really given by the same element under different circumstances of pressure and temperature is a fact now well known. The discoveries of Plücker and Mitscherlich show how illusory are many of the hopes that were at one time derived from spectroscopy. As the science advances, its difficulties increase; and, regarding instrumental shortcomings, Secchi says that, although we may hereafter be able to apply dispersive power with improved effect to the faint light of the stars, still it must be remembered that in the sun itself, where there is light enough for our present instruments, we find sufficient difficulty in the way of investigation. At the same time, it is certain that we have succeeded in fixing the position of the fundamental lines in the solar spectrum which will further serve us, as our knowledge of it increases, in decyphering the spectra of the stars.

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* *Astr. Nachr.*, No. 2032. † *Prodromo*, &c., 1876, p. 1. ‡ See Secchi, *Memoria* II., p. 9.

ADDITIONAL NOTE.

Since Mr. Birmingham's excellent Summary of the Results of the Spectroscopic Observation of Stars was written, considerable additions have been made to our knowledge in this most interesting branch of Science. Dr. Vogel has observed the spectra of all the stars down to mag. 7·5, found in the D. M., between – 2° and + 20°. Dr. Konkoly has undertaken and completed a similar work from – 0° to – 15°. Dr. Dunér has given to the world his invaluable memoir, "Sur les étoiles à spectres de la troisième classe." Professor Pickering has commenced photographing the spectra of all the stars down to the 8·0 mag. Up to March 1, 1887, no less than 15,729 spectra of bright and faint stars had been measured at Havard. Pechüle, during his expedition to observe the transit of Venus, observed a great number of southern stars spectroscopically.

Classification of Spectra.—Dr. Vogel has proposed a classification of spectra based upon the star's probable phase of development. He divides all the stars into three classes:—

I. Stars where the temperature is so high, that the metallic gases in their atmospheres only exert a feeble absorption. The metallic rays, therefore, are either very feeble or else invisible.

II. Stars where, as in our sun, the metals in their atmospheres make their presence known by strong absorption rays.

III. Stars where the temperature is so low that metallic compounds form, and maintain themselves in their atmospheres, and show themselves in large shaded bands.

He then proposes the following subdivisions:—

CLASS I.—Spectra where the metallic rays are extremely feeble, or wanting. The most refrangible parts, blue and violet, are very strong. The stars are white.

(*a*). Spectra where the hydrogen rays are very strong (Vega, Sirius, &c.).

(*b*). Spectra where the hydrogen rays are wanting (the brighter stars in Orion, with the exception of α).*

(*c*). Spectra where the hydrogen rays and D_3 are bright (γ Cassiopeiæ, &c.).

CLASS II.—Spectra in which the metallic rays are numerous and easily seen. The blue and violet relatively more feeble; in the red there are sometimes feeble bands. Colour, yellowish-white to deep yellowish-red.

(*a*). Spectra with numerous metallic rays, especially in the yellow and green. Hydrogen rays usually strong, but never so strong as in Class I *a*. In some stars they are invisible, and then there are generally visible in the red feeble bands, formed by rays very close together. (Aldebaran, Arcturus, &c.)

(*b*). Spectra where, besides dark rays and isolated bands, there are many bright lines. (The temporary stars, and the stars of Wolf and Rayet, &c.).

CLASS III.—Spectra where, besides metallic rays, there are numerous dark bands in all parts of the spectrum, and where the blue and violet are remarkably feeble. The stars are orange or red:—

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* At Greenwich the hydrogen lines have, however, been seen and measured repeatedly in these stars.

(*a*). The dark bands fade away towards the red (α Herculis, and α Orionis, &c.).

(*b*). The bands are very large, and the principal ones fade away towards the violet (19 Piscium, &c.).

While spectroscopists agree over types I. and II., types III*a* and III*b* have led to great divergence of opinion. On the side of a division into three types we have Vogel, Dunér, Konkoly; on the side of four types we have Secchi, D'Arrest, Pechüle, Pickering. The remarkable Paper read before the Royal Society, on Nov. 17, 1887, by Mr. Norman Lockyer, entitled a "Preliminary Note on the Spectra of Meteorites," and under this title dealing with the meteoric formation of the heavenly bodies, if accepted, must do away entirely with either scheme of classification. Mr. Lockyer divides the whole of the heavenly bodies into three stages—(1) increasing heat; (2) condensation; (3) subsequent cooling. Under the first heading come nebulæ, temporary stars, comets, and stars of Class III*a*; under the second heading come stars of Classes I. and II.; under the third come some stars of Class II., such as the sun, and stars of III*b*, or Secchi's IV. type. Borne out, as this theory is by careful experiments, and by the discovery that certain stars of type III. have bright lines as well as bands, it must go far to revolutionize our notion of the physical constitution of the heavenly bodies. It has seemed well to the writer, therefore, to retain the divisions of Secchi in the following pages as regards types III. and IV., and certainly the appearance of the spectra of two normal stars of types III. and IV. is so widely different, that it seems natural to place them under two separate headings. It may be remarked in passing, that while there are some stars which show spectra between II. and III., and III. and IV., there seem to be none which show any appearance of approximation between II. and IV., as required, apparently, by Mr. Lockyer's Paper.*

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* When the F. line appeared so brilliantly in R Cygni, in Aug. 1888, I could not recognize the III-type spectrum which had been previously observed by Dunér. Copeland (private letter) believed it III-type; but Maunder (M. N., XLIX., No. 5, p. 306) found that the general spectrum of the star appeared to be that of Secchi's fourth type. In 1889 the spectrum was again normal III-type, and the F. line hardly visible.

Description of Spectra.—Vogel and Dunér find ten prominent bands in the stars of type III. These bands have been carefully and repeatedly measured by them, and the following Table exhibits the means of all their measurements (Dunér, *Sur les étoiles*, &c., p. 120):—

		Vogel.	Dunér.
Band 1,	Commencement, . .	668· μμ.	663·8
	Middle, ...	657· „	—
	End, ...	648·8 „	649·5
Band 2,	C., ...	629·8 „	627·3
„	E., ...	616·2 „	616·3
Band 3,	C., ...	596·8 „	594·6
„	E., ...	586·7 „	585·5
Band 4,	C., ...	564·9 „	564·2
„	E., ...	559·8 „	559·2
Band 5,	C., ...	551·5 „	550·2
„	E., ...	545·2 „	545·1
Band 6,	C., ...	528·1 „	526·9
„	E., ...	524·3 „	524·0
Band 7,	C., ...	522·2 „	521·3
„	E., ...	516·8 „	516·8
Band 8,	C., ...	503·0 „	503·5
„	E., ...	495·9 „	495·8
Band 9,	C., ...	483·0 „	485·5
„	E., ...	476·6 „	477·0
Band 10,	C., ...	473·3 „	—
„	E., ...	460·7 „	—

Dr. Dunér, in the description of the spectrum of each star, makes mention of the bands specially seen.

In the same manner, the bands in the stars of the IV. type have been measured as follows:—

	Vogel.	Dunér.	Dunér's Number.
Commencement of spectrum, .	660 :: μμ.	—	—
Band, ...	656 : ,,	—	—
Band, ...	622 : ,,	621	2.
Band, ...	606·5 ,,	604·8	3.
Ray in a band, ...	589·3 ,,	589·8	4, maximum.
End of band, ...	584·8 ,,	—	—
Ray, ...	575·7 ,,	576	5.
Ray, commencement of a band,	563·1 ,,	563·3	6, commencement.
Ray, ...	552 : ,,	551 : :	7.
Ray, ...	544 :: ,,	545 :	6, end.
Group of rays, ...	528 : ,,	528·3	8.
Ray, commencement of a band,	515·9 ,,	516·3	9, commencement.
Ray, ...	513·2 ,,	—	—
		496 :	9, end.
Commencement of a band, . .	472·9 ,,	472·7	10, commencement.
		463 : :	10, end.
Band, ...	437 :: ,,	437	End of spectrum.
End of spectrum, ...	450 :: ,,	—	—

As regards the cause of absorption in these IV.-type stars, Dunér comes to the same conclusion as Secchi, viz., that the principal bands are due to absorption exercised by a carbon compound in the stars' atmospheres (*Sur les étoiles*, &c., p. 122).

The notes of exclamation after the type refer to the intensity of the spectrum. Thus, !!! shows it to be superb; !! very fine; ! that it is fine. When there is no note of exclamation, then the character of the spectrum is undoubted, but feebly developed (Dunér; *Sur les étoiles*, &c., p. 13). Vogel uses the same expressions, but in a slightly different sense.

Number of Stars of the III. *and* IV. *Types.*—Dunér (pp. 124, 125) finds that the total number of these interesting objects may be obtained by multiplying by $\frac{4}{5}$ the number of stars of any magnitude, and dividing the result by 15 for type III., and 750 for type IV. From this he finds the following results for the Northern heavens:—

Magnitude.	Obs.	Cal.		Obs.	Cal.	
1·0–1·9	2	1	for type III.	0	0	for type IV.
2·0–2·9	5	3	,,	0	0	,,
3·0–3·9	9	11	,,	0	0	,,
4·0–4·9	31	28	,,	0	1	,,
5·0–5·9	88	90	,,	2	2	,,
6·0–6·9	134	30	,,	11	8	,,
7·0–7·9	151	—	—	18	24	,,
8·0–8·9	37	—	—	14	—	—
9·0–9·9	18	—	—	10	—	—

He concludes that our knowledge of type III. stars is complete to 5·9, and of type IV. to 7·5. Dr. Dunér's conclusions seem to the writer to be certainly correct as regards type IV., since only one star of 7·5 mag. has been found with the 17¼-inch north of the equator.

The total number of stars of type IV., at present known, is as follows:—

Magnitude.	Known.	New, found with the 17¼.	Total.
5·0–6·0	4	0	4
6·0–7·0	14	1	15
7·0–8·0	18	4	22
8·0–9·0	12	25	37
Below 9.	6	22	28
Variable.	9	2	11
	63	54	117

The III.-type stars are of course much more numerous. Hardly any part of the sky can be swept with the 17¼-in. without coming across some new ones.*

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* Up to the present date (Nov., 1889) nearly four hundred new third-type stars have been found in the sweeps made with the 17¼-in.

Distribution of the III. *and* IV.-*Type Stars.*—Dr. Dunér finds that the stars of type IV. have a remarkable tendency to collect near the Milky Way. He gives the following Table, assuming the position of the Pole to be for 1900 R. A. XII.^{h} 42^m, Decl. + 26°·8 (Heis, *Atlas Cœlestis Cat. Stellarum*, p. viii.).

Galactic Polar Distance.	Number of Stars.	Mean Magnitude.
P = 0°–35°	3	6·6
„ 35 –60	8	6·6
„ 60 –70	8	7·2
„ 70 –80	13	7·4
„ 80 –90	29	8·3

This Table shows, conclusively—

(1) That 70 per cent. of the stars of type IV. lie within 20° of the Milky Way.

(2) That the magnitude increases with the distance from the Milky Way.

Of the 54 new IV-type stars found with the 17¼-in. only two lie at any distance from the Milky Way.

Dr. Dunér finds a tendency in these stars to collect into groups at R. A. 305°, Decl. + 40°, and R. A. 85°, Decl. + 25°; but, as he points out, this is the place where the stars, in general, are most numerous. My own observations show groupings at—

R. A.	Decl.
105°	+ 0°
85	+ 30
52	+ 60
305	+ 36

The winter galaxy seems to be, on the whole, richer than the summer one. Dividing the galaxy into two parts from R. A. 8°, Decl. + 64°, to R. A. 113°, Decl. – 20°, which we will call A, and R. A. 8°, Decl. + 64° to R. A. 263° – 20°, which we will call B, we find A has 52 stars, and B has 31 stars.*

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* Since these words were written several additional stars have been detected, but the proportions are not altered thereby.

The stars of type III. seem much more uniformly scattered throughout the heavens. My observations show tendencies to group at—

R. A.	Decl.	R. A.	Decl.
85°	+ 40°	215°	+ 30°
100	0	248	40
107	50	283	40
195	0	309	17

the one at 283° + 40° being the most remarkable. (See "Observatory," July, 1887, pp. 258, 259.)

The following observations of the spectra of stars are taken from—

(1). *Secchi*, . Memorie della Societa Italiana de' XL., 3^a serie, vol. I., 1867.
Memoria II., Sugli Spettri Prismatici, &c., 1868.
The Paper, Sugli Spettri, &c., in Atti dell' Accademia Pontificia, &c., March, 1872.
Prodromo di un Catalogo; Mem. Italian Spectroscopic Society, vol. V., 1876.
His Catalogue of 1867.
(2). *D'Arrest*, A. N., Nos. 2009, 2016, 2032, 2044.
(3). *Vogel*, . A. N., 2000.

The new material from—

Vogel, . . Spectroskopische beobachtungen der sterne bis einschliesslich 7·5 ter grösse in der zone von – 1° bis + 20° declination, and other Papers.
Konkoly, . Spectroskopische beobachtung der sterne zwischen 0° und – 15° bis zu 7·5 ter Grösse.
Pickering . Stars with remarkable Spectra, A. N., 2376, 2405.
Pechüle, . . Expédition danoise pour l'observation du passage de Vénus, 1882.
Dunér, . . Sur les étoiles à spectres de la Troisième classe.

My own observations consist of those in publication No. 1, Wolsingham Observatory, and in A. N., 2788, 2825, 2852, 2883, 2919, and of many hitherto unpublished. A description of the spectroscope used will be found in the "English Mechanic," Jan. 14, 1887, p. 430. It consists simply of a compound direct vision prism placed immediately before the eye-piece.* The observations of faint stars, of stars of small altitude, and of stars where the type is not pronounced, must be considered as provisional only.

DETAILED SPECTROSCOPIC OBSERVATIONS.

No.

1. 1887, Dec. 4, fine spectrum; deep bands: Dec. 6, glimpses of bands, and probably III. type.—*Espin.*
2. *Vogel* (Spect. Beob.); 1881, Nov. 20, rothgelb, III. (II *a*).
3. Type III.; *Pickering* (A. N., 2376). *Dunér;* yellowish-red, III.!! Bands 2–8 are strongly marked, but not very large. Those in the red are superb.
4. Intensely red; III. type; faint zones. *Secchi,* Prodromo, &c., 1876. *Dunér;* IV.! three zones, of which the blue is extremely pale. Band 6, very large and strong. Perhaps band 4 is also visible.
5. *Pickering* (A. N., 2376). Bands.
6. 1887, Dec. 6, III.!—*Espin.*
7. *Dunér;* rouge-jaune foncé, III. The bands are feeble, but of an extraordinary size, especially in the green and blue.
8. *Dunér;* rouge-jaune foncé, III.!!! The spectrum is not superb in the ordinary sense, but that which makes it without parallel is the cir-

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* Since the 17½-in. has been removed to Tow Law, three spectroscopes have been used, all on the same plan. No. 1 has one small compound prism, before an eye-piece magnifying 100 times; No. 2 is the one mentioned in the text; No. 3 consists of two large compound prisms, and well resolves the D line. By increasing the space between the prisms and the eye-piece, greater dispersion can be obtained. With the prism close to the eye-piece α Orionis shows a banded spectrum. When the prisms are removed two inches the bands are resolved into innumerable fine lines.

No. 8—*continued.*

cumstance that it does not absolutely resemble the normal third type, and still less the fourth type spectrum. In the yellowish-red there are two bands tolerably marked, fading towards the red side of the spectrum; at the bluish-green there are also two or three rather feeble bands. But where in the normal III. type the bands 4 and 5 are found, there are two bands strong and large. At the position of band 10 I perceived, on Oct. 11 (1882), a strong band ($\lambda = 466$). It appears, then, without doubt, that the spectrum is really III. type, but with strong irregularities in the relative intensities of the bands. For further note, see Dunér, p. 83.*

9.

10. *Dunér;* IV. type, with three zones, well separated. I glimpse, at times, the yellow sub-zone, and feebly the band 4.

11. Bands, but indistinct, 1886, Nov. 30. 1889, March 9, III.!—*Espin.*

12. 1889, Nov. 28, 6·5; pale orange red; III.; faint bands.—*Espin.*

13. 1887, Oct. 20, bands; IV. (?)—*Espin.*

14. 1889, Nov. 28, 8·7; pale red; III.; faint, large bands.—*Espin.*

15. 1889, Nov. 27, 7·0; yellow; II. type (?)—*Espin.*

16. 1887, Nov. 14, too faint.—*Espin.*

17. 1887, Nov. 14, possibly III.—*Espin.*

18.

19. *D'Arrest;* very red. Spectrum not uniform, and probably IV. (Viertel jahrsschrift der. Astr. Ges. IX. jahrg., p. 255). *Dunér;* rouge-jaune foncé. IV. type, with four zones, of which the ultra blue is excessively feeble. The band 6 is more feeble than is usual, which, perhaps, explains why D'Arrest was uncertain about the nature of the spectrum. The band 9 is very large and deep; the band 4 is fairly visible.

20. 1889, Nov. 28, III.!!! with bright lines.—*Espin.*

21. 1887, Nov. 14, 7·0; yellow; sp. cont.—*Espin.*

22.

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* For the subsequent discovery of bright lines in this star's spectrum, see the section "On the Stars with Bright Lines in their Spectra."

No.

23. 1886–7, several obs.; bands; and once clearly III. type.—*Espin.*
24. 1887, Dec. 17, spectrum apparently continuous.—*Espin.*
25. 1888, Feb. 16, pale orange-red, III. (?) feebly developed.—*Espin.*
26. Rose colour; spectrum discontinuous, with yellow and green zones; always too low: 1867, Dec. 20. 15th June, 1868.—*Mem.* II. Red-orange; fine third type. *Secchi*, Prodromo, &c., 1876.
27. Only 8 mag.; nothing particular; too small: 1868, Jan. 15.—*Mem.* II. Fiery red; diffused spectrum. *Secchi*, Prodromo, &c., 1876. *Pickering* (A. N., 2376); type IV. (?) Bands distinct; fine specimen. *Vogel* (Spect. Beob.); 1881, Feb. 18; mag. 8·8; röthlich gelb; III.!! *Dunér;* rouge-jaune; III.!! The bands are very large and deep. The nature of the spectrum is undoubted.
28. 1887, Nov. 14, bands; IV. (?)—*Espin.*
29. 1887, Dec. 14, spectrum seems to terminate abruptly; may be IV.—*Espin.*
30. 1887, Dec. 17, apparently continuous, but star too faint.—*Espin.*
31. 1887, Nov. 14, bands: (?) Dec. 16, probably III.—*Espin.*
32. 1888, Feb. 16, 7·2; orange-red; III.!; bands large, but faint.—*Espin.*
33. *Vogel* (Spect. Beob.); 1880, Nov. 29, gelb; III.
34. *Dunér;* III.! (?). The bands are so large that it may, perhaps, be IV.
35. *Pickering* (A. N., 2376); bands. *Dunér;* III.! well-developed. The bands are very large, especially in the green and blue.
36. *Pickering* (A. N., 2376); broad, well-marked bands. *Dunér;* III.!! In spite of the feebleness of the star, the bands appear very large and deep. In the green and blue there are absolute gaps.
37. 1886, Nov. 18, bands suspected. 1887, Dec. 6, spectrum apparently continuous.—*Espin.*
38. *Secchi*, Prodromo, &c., 1876, No. 21; type III., with columns well-marked, like μ Geminorum. *D'Arrest* (A. N., 2016); star 6·6; gelb röthlich. Well-marked columns. Every interval sharp and dark. The star itself, perhaps, somewhat variable. *Dunér;* III.!! The bands 2–9 are strongly developed; very large and deep.
39. 1887, Dec. 16, III.!!! deep bands.—*Espin.*
40. 1887, Dec. 4: Dec. 7, bands, probably III. type.
41. 1886, Nov. 18, III. (?)—*Espin.*

No.

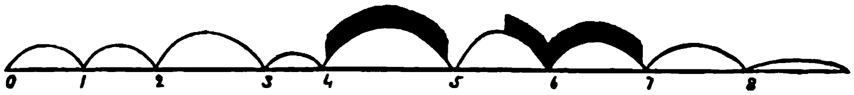
42. *Secchi;* red; nothing particular; must be variable: 20th Dec., 1868.—*Mem.* II.

43.

44. *Secchi;* orange, full of yellow; not sure of the star: 15th Jan., 1868.—*Mem.* II.

45. *Secchi;* diffused spectrum. Prodromo, &c., 1876.

46. *Secchi;* beautiful ruby-red; magnificent spectrum, of the type of β Pegasi, but with the bright lines more marked, and the dark intervals blacker; columnar, the columns partly decomposed into lines, as in that star. The following diagram shows the disposition of the columns, the curves indicating the intensity of light: 27th Nov., 1867:—



0–1: Magnificent deep red. **1–2:** orange-red, very bright. **2–3:** golden yellow. **3–4:** delicate pale green. **4–5:** decided green, subdivided by fine lines. This zone is divided by a strong line of magnesium. **5–6:** blue, fine and decided colour. **6–7:** indigo. **7–8:** violet. The remainder faintly luminous.

All the columns brighter on the side of the red.—*Mem.* II. When the star was of 5–6 mag., and visible to the naked eye, the spectrum showed a perfect type of α Herculis, and degree of light equal to α Persei.—*Catalogo*, &c. 2nd Dec., 1868: magnificent object; only 6 mag., but bright and red; lines most perfectly defined; columns resolved; intervals perfectly black. 8th Feb., 1869: scarcely 8 mag.; red, and shows the columnar spectrum, or rather a few discontinuous lines, the brightest appearing in the green like isolated threads of silver; the type confirmed; and it is seen that the diminution of the light depends on the widening of the absorption zones, because the bright lines remain most brilliant.—*Sugli Spettri*, &c., *estrato dagli Atti dell' Accademia Pontificia*, &c., Marzo, 1872. [The last remark agrees well with Vogel's obs. of R Geminorum, where the bright lines seemed not to vary with the size of the star.—*Bm.*] *Vogel*

No. 46—*continued.*

(A. N., 2000). The star was observed on March 2, 1874, the maximum not occurring until the 5th April afterwards. The light was feeble and reddish-yellow. On March 4 and 5, a band spectrum was evident, similar to that of α Herculis; the bands, especially two in the green, were deep black, so that the intervening part of the spectrum appeared strikingly bright by contrast. Unfortunately, the unfavourable weather prevented any further investigations of the phenomena described by Secchi in the *Comptes rendus* (tom. LXIV., p. 346), as follows:—"Mais au fur et à mesure que l'étoile gagne éclat, les raies noires du jaune et les premières du vert paraissent diminuer de netteté, et devenir moins noires." For the rest, Secchi's observations were confirmed. *Dunér;* rouge-jaune; sp. III.!!! *tout-à-fait incomparable.* The bands 1–2, and also 6, are extraordinarily large and black. In addition, there are secondary bands and visible rays. Even in the relatively feeble phases the spectrum is discontinuous. (In the case of this star and U Orionis, R Leonis, R Aurigæ, I have suspected that the spectrum is much more marked as the star is increasing than it is as it decreases.—*Es.*)*

47. III. type.—*Espin.*
48. 1887, March 15, 8·7; bands; III. type.—*Espin.*
49. *Dunér;* jaune-rouge; III.! In spite of the feebleness of this star, the nature of the spectrum is undoubted. The bands are large and deep.
50. *Dunér;* III.! The bands are very well-marked and large, especially in the green and in the blue.
51. 1887, Dec. 6; III.!!!—*Espin.*
52. 1888, Feb. 16, spectrum not quite uniform; bands suspected, especially in the violet; III. ?—*Espin.*
53. 1887, Dec. 14; III.!—*Espin.*
54. 1887, March 2; IV.? moon too bright. 1888, Feb. 16, too faint for spectroscope.—*Espin.*
55. *Secchi;* very small; zones apparently, but not certain.—*Mem.* II. Red; III. type; faint.—*Prodromo*, &c., 1876.

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* For the account of the bright lines detected by Professor Pickering, see section "On the Stars with Bright Lines in their Spectra."

No.

56. *Vogel* (Spect. Beob.); 1881, Jan. 26, 7·8; gelblich roth; III. ! ! !—*Dunér;* rouge-jaune; III.; very feeble, but the bands are enormously large, and deep in the bluish-green.

57. *Pickering* (A. N., 2376); bands suspected. *Dunér;* rouge-jaune foncé; IV. ? of three zones. The bands are large, but the spectrum is very feeble, and the nature a little uncertain; p. 84, IV. ? III. Having examined this star on three nights—12th, 13th, 15th March, 1885—I have a suspicion that it may possibly be III. In one spectroscope it resembles IV., in another III. The bands are large, and undoubtedly visible.

58. *Dunér;* IV., with two, or perhaps three zones. The spectrum is very feeble, but its nature hardly doubtful; p. 84; IV., with three zones, almost certain, but feebly developed. The bands 6 and 9 are large; the blue zone is not feeble.

59.

60. 1887, Dec. 14, III. ?—*Espin.*

61.

62.

63. 1887, Nov. 15, strong bands, probably III.—*Espin.*

64. *Pickering* (A. N., 2376); type IV.; fine specimen. *Dunér;* IV. ! ! ! with 4 zones, of which the blue one is rather brilliant, but the ultra-blue excessively feeble. The principal bands are very large and very deep. Also the bands 4 and 5 are visible; p. 85; IV. ! ! ! with 4 zones, of which the blue is more than ordinarily brilliant, but the ultra-blue very feeble. Band 6 is not sensibly more feeble than 9, and in general the principal bands are, by reason of the light of the star, more strongly marked that those of the spectrum of 152 Schj. The band 4 is considerably more strong than 5. Once I thought I glimpsed also bands 2 and 3.

65. 1887, Dec. 14, spectrum apparently continuous.—*Espin.*

66. 1887, Dec. 14, found while observing last; IV. type! Dec. 21, IV. !—*Espin.*

67. *Pechüle;* 1882, Dec. 14, III. (IV. ?).

68. 1886, Nov. 30, weak bands ?—*Espin.*

No.

69. *Secchi;* yellow, but too small. Bessel's 7 mag. stars are always small; Jan. 15, 1868.—*Mem.* II.

70. *Pickering* (A. N., 2376); type III. *Dunér;* III.! The star is too low; but the bands in the red, up to those in the bluish-green, are well seen and rather large.

71. *Dunér;* III.; feebly developed.

72. 1887, Dec. 14, III.?—*Espin.*

73. 1888, Oct. 3, probably III. type.—*Espin.*

74. 1887, Dec. 16, strong bands, and probably III. type.—*Espin.*

75. *Dunér;* rouge-jaune foncé; IV.! with three zones, of which the red and green are brilliant, but the blue extremely feeble. The yellow subzone is well visible, but I did not perceive with certainty the band. In addition, I see an extremely feeble band in the red, probably 4. The star is only 7·5 at most; p. 85, IV.!! The yellowish-red zone is very brilliant; the blue extremely pale. The bands 4 and 5 are undoubtedly visible: 4 stronger than 5.

76. 1886, Nov. 30, bands? 1887, Dec. 16, III.!—*Espin.*

77. 1888, Jan. 10, III.! Feb. 16, 8·3; red; III.!! bands not deep.—*Espin.*

78. 1886, Nov. 30, spectrum apparently continuous.—*Espin.*

79. 1888, Feb. 16, 5·5; pale orange; spectrum continuous.—*Espin.*

80.

81. 1887, March 1, IV.!! 1888, Feb. 16, IV.!!—*Espin.*

82. 1886, Nov. 30, weak bands; III. 1887, Dec. 4, III.!!—*Espin.*

83. *Vogel* (Spect. Beob.); 1881, Feb. 18, III.!

84. 1886, Nov. 2, bands? III.?—*Espin.*

85. *Secchi;* rossa gialla; spectrum III.—*Prodromo.* *Dunér;* no star of III. type seen here. *Espin;* 1888, Jan. 19, III.?

86. *Secchi;* pale red; fine spectrum, with abundant red, and various lines; not quite columnar: Jan. 15, 1868.—*Mem.* II. *Espin;* 1888, Jan. 19, III.?

87. 1886, Nov. 21, bands: Nov. 30, III.!—*Espin.*

88.

89. *Vogel* (Spect. Beob.); 1881, Feb. 24, III. *Espin;* III.!!! several obs. The spectrum is very fine, and the bands numerous but not deep.

No.

90. *Secchi;* orange-yellow, and traces of zones, but star small, and scarcely 7 mag.: Jan. 7, 1868.—*Mem.* II. Red; III. type; zones. *Prodromo,* &c., 1876. *Vogel* (Spect. Beob.); 1881, Jan. 5, estimated 8·0: gelblich roth; III.!! *Dunér;* rouge-jaune foncé; III.! with bands so large that one might believe the spectrum IV. The bands 7 and 8 are the largest.

91.

92. *Secchi;* yellow-red; well marked in lines, but not in zones; fog makes observation difficult: Jan. 15, 1868.—*Mem.* II. Type III.; lines.—*Prodromo,* &c., 1876.

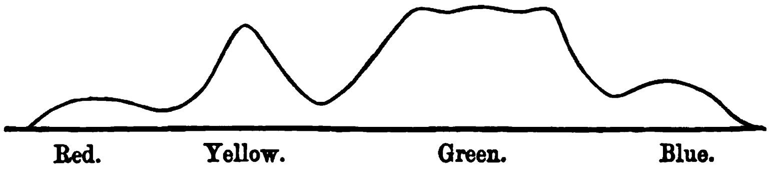
93. *Secchi;* III. type; excellent; dark zones in the red.—*Prodromo,* &c. 1876. *D'Arrest;* excellent III. type spectrum. Bands in the red peculiarly black. *Dunér;* III.! The bands 2–8 are visible, but only 2 and 3 are strong. *Espin;* 1887, Dec. 4, III. type; very beautiful, but the bands are faint.

94.

95.

96. 1886, Nov. 30, III.!!! very deep bands.—*Espin.*

97. *Secchi;* magnificent star of the IV. type; the red exceedingly faint; beautiful yellow zone; then a lacuna; then yellow-green; then another lacuna, and extremely faint blue. The colour in the finder is bright red: Jan. 16, 1868.—*Mem.* II. *Dunér;* rouge-jaune foncé; IV.!! with 3 zones. The principal bands are very large and very deep. The yellow sub-zone and the band in it are well seen. The most refrangible ray in the green zone is also glimpsed at intervals. The red is by no means feeble; p. 85. 1885, March 12, IV.!!! Bands 4 and 5 certainly seen.



98. 1886, Nov. 21: Nov. 24, IV. 1887, March 15, IV.!!—*Espin.*

99. 1888, Jan. 10, glimpses of bands, probably III.—*Espin.*

No.

100. 1887, Dec. 21, III. ! ! !, by glimpses, with very deep bands.—*Espin.*

101. *Secchi;* small 8 mag. star; pale red; three zones, faint towards the red; IV. type, with one bright yellow zone. Star so feeble as to require attention to see it at all; still the zones are quite distinct: Jan. 7, 1868.—*Mem.* II. *Vogel* (Publicationen 14); a band spectrum similar to Schj. 152, but showing a difference in the relative intensities of the bands. Band at 589 feeble; line 576 dark; band beginning 563 very feeble; band beginning 516 very broad and very intense; band 473 strong. *Dunér;* presque rouge absolu; IV. !, with three zones. The green zone the most brilliant, the blue very feeble. Band 9 strong, but 6 rather pale.

102. 1887, Nov. 3, bands ? Nov. 24, IV.—*Espin.*

103. *Vogel;* 1881, Feb. 24, estimated 9·4; röthlich gelb; III. ?

104. 1886, Nov. 21, IV. ? 1887, Dec. 16, star faint, possibly IV., but difficult.—*Espin.*

105. *Secchi;* pale rose colour; zone spectrum; lines sharp, but columns not prominent; III. type: Jan. 7, 1868.—*Mem.* II. *Vogel* (Spect. Beob.); 1880, Jan. 18, 19; röthlich gelb; II*a* type. *Dunér;* jaune-rouge; III. type; the bands are in general feeble, and 2, 3, 7, 8 alone are well seen.

106.

107. 1887, Dec. 16, III. type.—*Espin.*

108. *Secchi;* spectrum uniform, but not sure of the star: Jan. 15, 1868.—*Mem.* II.

109. *Secchi;* spectrum uniform (if the right star); 9 mag.; Hind's crimson. —*Mem.* II. *D'Arrest* (A. N., 2032). In Jan., 1875, at maximum, when the star was of 7·8 mag.; a most splendid spectrum of the IV. type, but the spectrum is not in every year visible, and never for more than a short time. *Vogel* (A. N., 2000) remarks, that Secchi examined the spectrum of this star only at the time of minimum, when details could not be seen. Dr. Vogel finds the spectrum IV. In the yellow and in the green a broad band; then the bands were especially in the green; the more refrangible parts of the spectrum were strongly absorbed; red and yellow were, on the

No. 109—*continued.*

other hand, rather intense (see D'Arrest's observations). *Dunér;* rouge-jaune foncé; IV.! The two zones, red and green, are brilliant. The blue zone is exceedingly feeble.

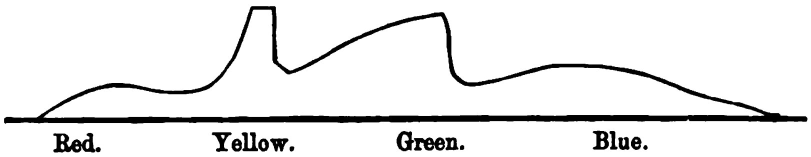
110. 1886, Nov. 3: Nov. 24; IV.!!—*Espin.*

111. *Pickering* (A. N., 2376); broad bright band in red, narrow one in green. *Dunér;* III.!! The spectrum is very feeble, but the bands are of enormous size. In spite of all this the spectrum does not seem doubtful.

112. 1887, Dec., several trials, not found.—*Espin.*

113. 1886, Nov. 18, bands? 1888, Feb. 7, III.!—*Espin.*

114. *Secchi;* deep yellow; spectrum composed of groups of lines in the red, yellow, and green: Nov. 30, 1867. Dec. 15, a group of lines in the red, another in the orange-yellow, as if in continuation; then a great lacuna; then a bright green; and then, after a second lacuna, a faint zone of violet. On Jan. 15, 1868, the light curve was as follows:—



red; fourth type, with zones. *Prodromo*, &c., 1876. *Vogel*, 1873, (Publicationen, 14). The following bands and stripes were seen:—622, strong; 589, moderately feeble; 576, not very strong, somewhat shaded; 563, beginning with one very large, intense, dark band; 516, very large and dark band; 473, large and dark. *Vogel* (Spect. Beob.), 1880; gelblich roth; IV.!!! *Dunér;* presque rouge absolu; IV.!!!, with four zones. The bands 2, 3, 4, 5, 6, 9, 10, are visible; 9 is very deep; 6, a little more feeble. The ultra-blue zone is almost invisible.

115. 1887, Dec. 7. Believed to be IV. 1888, Jan. 10, too faint. 1888, Dec. 31, III.!!! very large and deep bands.—*Espin.*

116.

117. *Dunér;* rouge-jaune foncé; IV., with three zones, of which the green zone is the most brilliant.

No.

118. *Vogel* (Spect. Beob.), 1880, Jan. 19, gelblich weiss; II*a*. *Konkoly*, 1884, Jan. 18, 7 mag.; gelb; II*a*.

119. *Konkoly;* 1884, Jan. 18; II*a*.

120. *D'Arrest* (A. N., 2032); star 6·7; gelblich. Splendid III. spectrum, typical columns with almost exactly equal separation. *Dunér;* rouge-jaune; III.!!! The bands are magnificent, and visible, at least, from 1 to 9, inclusive. The spectrum is one of the most superb in the heavens. *Konkoly;* 1884, Feb. 20, IV.! *Espin;* several obs., 1886–87, III.!!! most marvellous.

121. 1886, Nov. 18, 8·0 mag.; very red; III.!!!; the bands are extremely large and deep.—*Espin.*

122. *D'Arrest* (A. N., 2032); star, 8·8 mag.; feeble, but clearly-marked columnar spectrum III., quite distinct. No striking colour noticed. *Vogel;* 1880, Jan, 19, röthlich gelb; III.!! (Spect. Beob.). *Dunér;* rouge-jaune; III.! The bands are large and visible as far as the blue, where they are stronger than in the red. The entire spectrum is rather feeble.

123. *Dunér;* III.! very feeble, but the bands are very large; the nature of the spectrum seems undoubted.

124. 1888, Jan. 19. I suspect this star to be III. type.—*Espin.*

125. 1886, Nov. 3; bands? 1887, Dec. 16; IV.! one very deep band.—*Espin.*

126. 1888, Feb. 7; III. type. ?—*Espin.*

127. *Secchi;* faint, and must be variable; has lines, but feeble; seems scarcely 9 mag.: Jan. 16, 1868.—*Mem.* II. Red; IV. type, var. *Prodromo*, &c., 1876. *Dunér;* rouge-jaune; II*a*? not IV. at all. *Espin;* 1888, Jan. 19, possibly III. type.

128. 1888, Jan. 9, III. type.—*Espin.*

129.

130. 1886, Nov. 30, IV. type. 1887, Oct. 28, Nov. 4, Nov. 14, Dec. 4, Dec 16, star always too faint to be certain of its spectrum.—*Espin.*

131. 1888, Feb. 4, probably III., but only 8·8 mag.—*Espin.*

132. *Konkoly;* 1884, Feb. 20, III. II*a*.

133. *Dunér;* presque rouge absolu. The spectrum is extremely feeble, but

undoubtedly IV., with two zones only. Once I thought I perceived a trace of the blue zone. Band 6 is large and deep.

134. 1887, Dec. 6, 7, spectrum apparently continuous.—*Espin.*

135. 1887, Dec. 6, 7, spectrum apparently continuous; star too faint.—*Espin.*

136. *Konkoly;* 1884, Jan. 18, III. ?

137. 1888, Feb. 7, bands, and I think III. type.—*Espin.*

138. 1886, Nov. 18, III. ! ! broad and deep bands.—*Espin.*

139. *Konkoly;* 1884, Jan. 18, II*a*; very fine lines.

140. *Secchi;* full yellow, almost red; magnesium spectrum; that is to say, it has the black line of magnesium sufficiently precise, and, for the rest, the spectrum quasi-uniform: 15th Jan., 1868.—*Mem.* II. IV type, var.—*Prodromo*, &c., 1876. *Vogel* (Spect. Beob.); 1880, Jan. 19, gelb; II*a*. *Dunér;* jaune-rouge; II*a* ! perfectly certain. *Konkoly;* 1884, Jan. 18, gelblich roth; III. type.

141. *Secchi;* columnar, and really beautiful; yellow-orange, like α Orionis, and spectrum showing a magnificent type of that star, with columns resolvable into fine lines; colour, red-orange in a second observation: 15th Feb., 1868.—*Mem.* II. *D'Arrest* (A. N., 2016); 5 mag.; gelbröthlich; excellent III.-type spectrum. All bands dark and wide; like π Aurigæ. *Vogel* (Spec. Beob.); 1882, Jan. 14, röthlich gelb, III. ! ! *Dunér;* rouge-jaune; III. ! ! rather strongly marked. The bands 2–8 are visible.

142. Several observations, 1886–87; IV. !—*Espin.*

143. 1888, Jan. 9, III. ?—*Espin.*

144. 1888, Jan. 19, continuous ? but faint.—*Espin.*

145. 1887, Dec. 7, III. type by glimpses.—*Espin.*

146. 1887, Feb. 28. The spectrum did not seem either III. or IV.; there is one very broad band, and a suspicion of a bright line; on a subsequent night it was deemed to be certainly IV.—*Espin.*

147. *Secchi;* spectrum unequal; feeble at the green, which is pretty wide; like an incomplete IV. type, but all rather feeble.—*Mem.* II. *Vogel* (Spect. Beob.); 1882, Jan. 14, röthlich gelb, III. *Dunér;* rouge-jaune; continuous spectrum, or perhaps II*a*. *Espin;* 1888, Feb. 7, not quite continuous; perhaps III.

No.

148. 1887, Dec. 17, iv. (?) faint, and difficult on account of neighbouring star.—*Espin.*

149. 1888, Jan. 9, iii. (?)—*Espin.*

150. 1888, Jan. 10, spect. cont.—*Espin.*

151. 1888, Jan. 10, iii.—*Espin.*

152. *Dunér;* presque rouge absolu; iv. type, with three zones. The blue is exceedingly feeble.

153. *Dunér;* rouge-jaune foncé; iv. ! ! with three zones, of which the blue is very feeble. Sub-zone yellow is very brilliant, and the bands 4 and 5 well seen. Band 4 is narrow but rather strong. Twice I thought I glimpsed bands 2 and 3 also. The principal bands are very strong.

154. *Pechüle;* 1882, Dec. 8; iv. type.

155. 1888, Jan. 10; D. M. + 21°, 981; faint; apparently continuous.—*Espin.*

156. Several obs.; 1886–87, suspected iv., but never certain.—*Espin.*

157. 1888, Jan. 10, spectrum too faint.—*Espin.*

158. 1886, Nov. 30, iv. !—*Espin.*

159. 1888, Jan. 9, too faint, and too much interference from neighbouring stars.—*Espin.*

160. 1888, Jan. 9, no red star here.—*Espin.*

161. Several obs., 1887, '88, too faint.—*Espin.*

162. *Vogel* (Spect. Beob.); 1882, Jan. 13, gelb; ii*a* (?) iii.

163. *Espin;* 1886–7, iii. ! ! ! very deep bands. The spectrum has been observed by several observers, and is found to be finely developed iii. type. *Pickering;* bright lines.*

164.

165. 1888, Feb. 4, 9·0; reddish; nothing particular.—*Espin.*

166. 1888, Feb. 4, 8·5; pale orange-red; nothing particular.—*Espin.*

167.

168. *Konkoly;* 1884, Feb. 14, 6; weisslich gelb; i*a*; D and b, fine.

169.

170. *Pickering* (A. N., 2376); iii. type. *Dunér;* jaune-rouge; iii. ! The bands 2–8, and perhaps also 9, are visible. They are large, but not very deep. The bands in the red are strongest.

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* See the section " On the Stars with Bright Lines in their Spectra."

No.

171. *Pickering* (A. N., 2376); III. (?) *Dunér;* jaune-rouge; III. Bands 2, 3, 7, 8, are visible, but the spectrum is feebly developed.

172. *D'Arrest* (A. N., 2032); 8 mag.; dark red; superb specimen of the IV. type; far brighter and plainer than in other stars of the same magnitude; broad light streaks between wide dark gaps, which quite break up this remarkable spectrum. *Dunér;* rouge-jaune foncé; IV.!! Three zones. The bands are large and black, but 6 is appreciably more feeble than 9. Perhaps the bands of the yellow sub-zone are also visible. For the rest the spectrum is not different to other spectra of the same kind.

173. 1888, Jan. 19, III.!—*Espin.*

174. 1887, Dec. 18, III.!!—*Espin.*

175. *Secchi;* ruby; IV. type, superb; very bright; broad bright streaks and dark intervals.—*Prodromo,* &c., 1876. *Dunér;* rouge-jaune foncé; IV.; very feeble, with three zones, of which the green is the most brilliant. The nature of the spectrum is pretty sure.

176. *D'Arrest* (A. N., 2016); 6 mag.; nearly colourless, with beautiful columnar spectrum. The second band in the red particularly large. *Dunér;* rouge-jaune; III.! Beautiful spectrum, in which the bands 2 and 3 are very large, and 4–8 very well seen.

177. 1886, Nov. 3, bands (?) 1888, Feb. 7, bands, probably III. type.—*Espin.*

178. 1888, Jan. 19, III. type.—*Espin.*

179. 1888, Feb. 7; spect. cont.—*Espin.*

180. 1886, Nov. 24, IV.!—*Espin.*

181. *Vogel;* 1882, Jan. 15, gelb; III.!

182. *Pickering* (A. N., 2376); III. type (?) *Dunér;* III. (?) The bands are extremely pale; 2, 3, 7 are the only ones glimpsed. The nature of the spectrum is uncertain. *Konkoly;* 1884, March 15, III. II *a*. *Espin;* 1886, Nov. 24, bands. 1887, Dec. 17, III.!

183. 1888, Jan. 9, IV. (?)—*Espin.*

184. 1886, Nov. 25, IV.!—*Espin.*

185. 1886, Nov. 3, III. type; deep bands.—*Espin.*

186. *Konkoly;* 1884, March 15, III. II *a*.

187. *Secchi;* bright deep red; 8 mag.; IV. type.—*Prodromo,* &c., 1876. *D'Arrest*

No. 187—*continued.*

(A. N., 2016); reddish star, 8 mag. (not brighter), with irregular spectrum of the IV. type. Spectrum indeed feeble, but surprisingly plain. Remarkably bright places in yellow, as the broader light streaks appear. *Vogel* (Spect. Beob.); 1882, Jan. 15, gelblich roth, IV. ! ! ! *Dunér;* IV. ! ! with four zones, quite normal, only the band 6 a little feeble. The blue zone is rather feeble, and the ultra-blue hardly visible. The yellow sub-zone is very brilliant, and the bands 4 and 5 well seen.

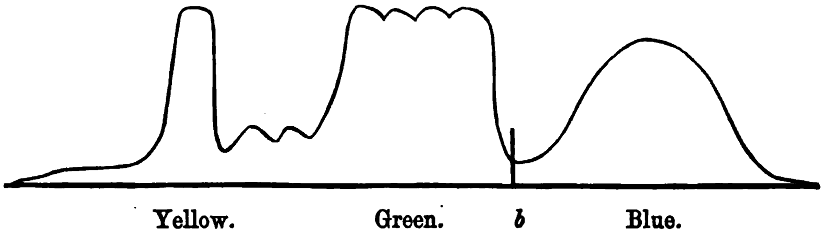
188. *Pechüle;* 1882, spectrum very feeble.

189. 1887, Dec. 21, IV. (?) bands.—*Espin.*

190. 1888, Jan. 28, 8·3; orange. Spectrum continuous.—*Espin.*

191. *Konkoly;* 1884, March 18, 7·5; weisslich gelb; I*a*.

192. *Secchi;* magnificent object; spectrum quite extraordinary. First a bright yellow line; then a lacuna with two faintly bright lines; then a green zone full of lines, and terminating with magnesium;



and, lastly, a fine blue zone. The star may be in some degree variable, as it appeared to Herschell at the Cape only orange, while now it is quite red; Feb. 15, 1858.—*Mem.* II. (Secchi, in his *Catalogo*, written in the previous year, described the star as of the type of α Herculis, with three bright zones and truncated spectrum (p. 14). It really belongs to type IV.) *Vogel* (Publicationen 14, 1874), very fine spectrum, remarkable in that the bands in the less refrangible part are especially marked. (Band 623, Int. 2; Band 590, Int. 5; deep line, 575·5, Int. 9; Band 564, Int. 5; Band 515, Int. 10; Band 473, Int. 7.) *Dunér;* rouge-jaune foncé, IV. ! ! ! with four zones. The principal bands are very strongly marked, but band 6 is more feeble than the others. The yellow and red sub-zones

No. 192—*continued.*

are well developed; the bands 2, 3, 4, and 5 not at all feeble. As for the rays 7 and 8, I could not see them, and I do not understand how Secchi means his "zona verde tutto righettata."

193.

194. 1886, Nov. 3, III.!! Deep bands. 1888, Feb. 13, bands notdeep.—*Espin.*

195. 1887, Dec. 11, III.!!!—*Espin.*

196. 1887, '88, nothing particular.—*Espin.*

197.

198. *Pechüle;* 1882, Dec. 8, spect. contin.

199.

200 *Pickering;* IV. type. *Dunér;* IV. type, with 3 zones, of which the blue is so feeble that it easily escapes attention. Band 6 is very large.

201. Several obs., 1886, '87; always too faint to be sure; several times suspected IV.-type spectrum; neighbouring star interferes.—*Espin.*

202. 1888, Jan. 26, 7·3; reddish; uncertain; too low.—*Espin.*

203.

204. 1887, Dec. 16, definition too unsteady: Dec. 17, bands, and I think III. —*Espin.*

205. 1887, Dec. 11, Dec. 14, IV.! type.—*Espin.*

206. 1886, Nov. 21, IV. type. 1887, Dec. 11, IV.!!—*Espin.*

207. 1888, March 10, 8·5; pale red; III. type; feebly developed.—*Espin.*

208. Several obs., 1886, '87, IV.!!—*Espin.*

209. *Pechüle;* 1882, Dec. 7, spectrum like II. type.

210. *Copeland;* banded spectrum. *Espin;* 1888, Feb. 13, bands; III.(?) image unsteady.

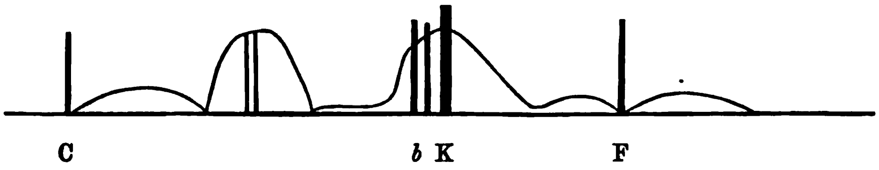
211. Several obs., 1886, '87, IV.!!—*Espin.*

212. *Konkoly;* 1884, March 20, II*a* III.(?) According to Weisse, mag. 8·9; broad lines.

213. *Secchi;* star yellow; spectrum with fine lines, and magnificent red; Jan. 16, 1868. A strong line in the green not coinciding with magnesium, but rather nearer the red.—*Mem.* II. *Pechüle;* 1882, Dec. 7, jaune; II. type. *Espin;* 1888, Feb. 10, 8·0; orange; III. (?)

214. 1888, Jan. 26, moonlight. Spectrum uncertain.—*Espin.*

No.
215. *Secchi;* most interesting object; bright line spectrum; F. of hydrogen, bright and beautiful; a bright line in the yellow-green, or yellow; a hazy bright line in the yellow; 8 magnitude: Feb. 8, 1869. It appeared to have the magnesium zone (or carbon ?), with the bright line of sodium (or rather near sodium), and seemed of the IV. type with bright hydrogen. The three columnar formations of the type were observed: in the yellow, a bright line, perhaps double; in the green a brilliant bright line; the spectrum was one of faint bands, with a bright red one. Compared with α Orionis, the green corresponded with magnesium, and the red with the hydrogen C; the bright of the yellow agreed with the bright line of Orion near D, and would seem to be the usual bright line of the chromosphere: Feb. 11. This star presented a spectrum analogous to that of T Coronæ, which appeared in 1866. On Feb. 14, 15, 1869, it showed the spectrum as in the diagram, where the ordinates represent bright lines, and the curves show portions of the continuous spectrum; the K line was brilliant and isolated, and appeared flanked by two black lines, which were decided enough, on a faintly luminous ground. A bright zone, b, followed with the lines of magnesium, or some other substance exceedingly close to it; then a yellow region, with a bright line which appeared double at intervals, but on account of the little dispersion of the spectrum it could not be confidently identified as the D line. Farther on was the C line of hydrogen, which scintillated at intervals, and seemed to end the spectrum.—*Sugli Spettri*, &c., Marzo, 1872, p. 17. Undoubtedly, the bright green belongs to magnesium, and corresponds with α Orionis; and the line at the extreme red is the hydrogen C. This is faint, and shows by flashes, but it is certain (*ibid.*, p. 28). The



No. 215—*continued.*

star was 7 mag., and either did not reach the 6th, or, if it did, it was during the full moon, and in bad weather. After the full of the moon only a 9–10 mag. could be found in its place. It showed similarity to T Coronæ, rapidly decreasing in light, so that the little star that remained presented only a very faint continuous spectrum (*ibid.*, p. 17). Mr. Birmingham gives the following abstract of Dr. Vogel's obs.:—"On March 5, 1874, the blue and violet were feeble. In the orange and red were perceived weak, dark bands, apparently; also there were numerous lines in the green; several bright lines were plainly visible, and especially when no cylindrical lens was used; then they appeared in the line-like spectrum like little knots of light. On March 12, the brightest line, with a wave length of 581, had dark bands on each side; weak bands apparently also in the blue. The maximum was on April 7, when the star was bright red, and the continuous spectrum had greatly increased in brightness. The bright lines, however, were now not better seen than they had been for a long time previously. On the contrary, they seemed less strikingly distinguished from the continuous spectrum. Dr. Vogel gives several measures of the lines, but taken under unfavourable circumstances that must detract from their value. He speaks confidently, however, of the bright lines of hydrogen or sodium. His observations on this point are quite opposed to Secchi's, as they appear in the *Comptes Rendus* (tom. LXVIII., p. 361), where the spectrum is described as 'un des ces rares exemples où la raie de l'hydrogène est brilliante. Elle présente encore d'autres bandes lumineuses, dont les principales correspondent à des bandes obscures dans le spectre de α Orion: ces bandes sont situées dans la région du magnesium (b), dans une position intermédiaire entre b et D.' On page 763 are further observations of the spectrum. When the star was only 9 magnitude, the spectrum appeared continuous; and Secchi goes on: 'nous avons donc été témoins ici d'une combustion d'hydrogène, et peutêtre de magnesium et de sodium, c'est-à-dire des substances qui, parmi les corps composant l'atmosphère solaire, ont les poids atomique ce

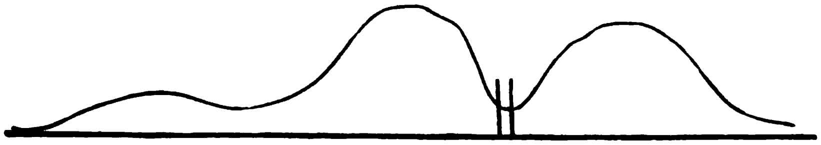
No. 215—*continued.*

plus faible.' Dr. Vogel then proceeds to compare Secchi's observations taken from the *Comptes Rendus*, with others of later date, and published in the Memoir, *Sugli Spettri*, &c., p. 17: Rome, 1872. These are considered by Dr. Vogel to show the slender grounds on which, as it appears to him, Secchi assumed the presence of hydrogen in the star, as the F line is not at all mentioned in the page referred to, and the C line was said to scintillate only at intervals. From this I must conclude that Dr. Vogel did not read the observation in pages 27, 28, where Secchi calls the F line '*bright and beautiful*,' and the C, while scintillating, no less certain. Dr. Vogel, in conclusion, repeats that the bright lines in the spectrum of R Geminorum were well seen a full month before the maximum; further, that as regards the relative light of the bright lines and the adjoining parts of the spectrum, the lines did not brighten towards the maximum in the same degree as the continuous spectrum, and he infers that the increase of the star is, therefore, not to be attributed to outbreaks of the gases that give the bright lines. This conclusion seems well supported by Secchi's observations of Mira, where the bright lines showed no decrease toward the minimum."

216. 1887, Dec. 14, IV. ! !—*Espin.*

217. *Vogel* (Spect. Beob.); 1880, March 29, gelblich roth; III. ! 8·2 mag.; blue very weak. *Dunér;* rouge-jaune foncé, III. I cannot decide if the spectrum is III. or IV. I glimpse nothing but two bands, large but pale.

218. *Secchi;* spectrum similar to Schj. 78; IV. type, but zones varying in intensity. A dark zone sufficiently marked divides the green from the blue, and there is a lacuna in the yellow. Though only 8 mag.,



No. 218—*continued.*

the red colour is decided: Feb. 25, 1868.—*Mem.* II. *Vogel* (1874, Publicationen, 14), clearly marked IV. type spectrum. The band in the green is the darkest; the maximum light of the spectrum lies in the orange and yellow; the bands there are proportionately very feeble. *Dunér;* rouge-jaune foncé, IV.!! with 3 zones. Band 6 is rather deep, and band 9 very large and obscure. Perhaps the bands in the yellow sub-zone are visible.

219. Jan. 28, definition unsteady; III., by glimpses, with deep bands. Feb. 10, III.!!—*Espin.*

220. *Secchi;* pale red; spectrum uniform; nothing particular: Feb. 23, 1868.—*Mem.* II. *Espin;* 1888, Feb. 7, III.!

221. *Secchi;* fine yellow; nothing particular: Feb. 26, 1868.—*Mem.* II. *Espin;* 1888, Feb. 8, III.!

222. 1886, Jan. 26, too low.—*Espin.*

223. 1888, Feb. 13, spectra of the two stars confused. III II*a*, uncertain.—*Espin.*

224. *Pechüle;* 1882, Dec. 8, II. type.

225. 1887, March 15, IV.!!, and query if not bright lines; certainly very peculiar. Dec. 17, singularly pronounced spectrum: Dec. 21, the spectrum is very extraordinary; IV. type, but parts so bright as to lead to the idea of bright lines.—*Espin.*

226. *Secchi;* red; uniform; second type. (?)—*Prodromo,* &c., 1876.

227. 1888, Feb. 10, spect. cont.—*Espin.*

228. 1888, Feb. 13, not found.—*Espin.*

229.

230. 1887, Dec. 9, IV.!; one very deep band.—*Espin.*

231. 1886, Nov. 22, 25, III.!!!; strong, and deep bands. 1888, Feb. 7, III.!!!; fine specimen.—*Espin.*

232. *Pechüle;* 1882, Dec. 17, spect. cont.—*Espin.* 1888, Feb. 13, III. type; (?) air unsteady.

233.

234. *Konkoly;* 1884, Feb. 19, 6·5; gelb; II*a.*!

235. 1887, March 23, IV.! 1888, Jan. 19, IV. type.—*Espin.*

236. 1888, Feb. 10, III.!—*Espin.*

No.

237. *Vogel* (A. N., 2000); max., March 31; observed on March 15, the colour of the star was red; the spectrum showed dark bands, and between them were places so intensely bright that it was doubtful whether they only appeared so by the effect of contrast, or were really bright bands. The state of the atmosphere prevented measuring till April 7, when the spectrum was found similar to α Orionis and β Pegasi. *Dunér;* rouge-jaune, sp. III.!! The bands are excessively large and deep through the entire spectrum, but especially in the green and blue.

238. *Dunér;* jaune-rouge; III.!! The bands 2–8 are well seen; 2, 3 are very deep. The small meridian altitude of the star renders the observations difficult, and not altogether certain. *Konkoly;* 1884, Feb. 20, gelblich roth; 5·5; III. type; poor example.

239. *Konkoly;* 1884, Feb. 21; without details.

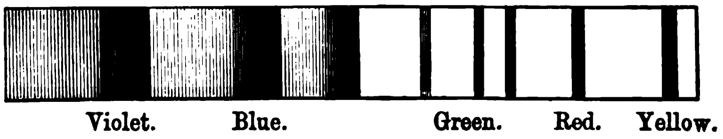
240. 1886, Nov. 29, IV.! 1888, Jan. 28, IV.! Bands very large.—*Espin.*

241. 1888, Feb. 10, III. type.—*Espin.*

242. *Vogel;* 1881, April 20 (Spect. Beob.); III.!

243. 1888, April 14, 7·0; pale orange red; II*a* III.—*Espin.*

244. *Vogel* (M. N., XL., No. 5, p. 294); 1879, Dec. 16: 1880, Feb. 7, the spectrum is highly interesting; the blue and violet are strongly absorbed, so that at the first glance only half the spectrum seems to exist. In the blue and violet three dark broad bands are plainly recognized. In the green and red there appear also to be bands, but they are too faint to be certainly distinguishable. On Feb. 7, Dr. Vogel found that D. M. + 8°. 1846, a yellow star, had a similar spectrum, except that it is not so clearly developed.



(From the above sketch it would appear that the spectrum is IV. type.)

245. 1888, April 14, too faint.—*Espin.*

246. *Pickering* (A. N., 2376); bands. (?) *Pechüle;* 1883, Jan. 6, rouge; spectrum seems continuous.

No.

247. *Dunér;* III.! feeble, but the bands are very large, especially in the green and in the blue.

248.

249. *D'Arrest* (A. N., 2032); bright red; 8 mag.; with very evident zone-spectrum; but requires good air on account of the smallness of the star. *Vogel* (Spect. Beob.); 1880, March 9, gelb; sp. II*a* (?) III. *Dunér;* jaune-rouge; III. (??); once only (1882, March 17) have I seen feeble traces of characteristic bands; all the other times the spectrum appeared continuous.

250. *Pechüle;* 1883, Jan. 6, spectrum, very feeble.

251. 1888, April 13, 9·0; pale red; III. type: bands faint.—*Espin.*

252. 1886, Nov. 25, IV. type.—*Espin.*

253. *Konkoly;* 1884, Feb. 20, IV. type. *Espin;* 1888, Jan. 26, moonlight; spectrum faint, but I do not think IV. type. Jan. 28 (during total eclipse), III. type; bands are faint. March 10, III.; (?) bands very feeble; star 7·0 mag.; orange red.

254.

255. *Pechüle;* 1883, Jan. 6, spect. cont.

256. *Pechüle;* 1883, Jan. 6, IV. type.

257.

258. *Pechüle;* 1883, Jan. 6, spect. cont.

259. *Pickering* (A. N., 2376); IV. type. *Dunér;* IV. type; very feeble, with two zones.

260.

261. In A. N., 2788, the observations really belong to Es., 248. 1887, March 22, III.!!! with very deep bands.—*Espin.*

262.

263. *Vogel* (Spect. Beob.); 1882, Feb. 12, gelblich roth; estimated 9·0; IV.! *Dunér;* rouge-jaune, III.! very well marked for the size of the star. Bands 2–8 are well seen.

264.

265. *Vogel* (Spect. Beob.); 1881, Jan. 25, gelb; III. type.

266.

267. *Pechüle;* 1883, Jan. 5, spect. cont.

No.

268. 1888, Feb. 10, III. ! bands obvious, although so low.—*Espin.*

269.

270.

271.

272. *Vogel* (Spect. Beob.); 1880, March 15, weisslich gelb; II*a.* 1888, Feb. 10, not continuous; probably III. II*a.*—*Espin.*

273.

274. *Dunér;* III. ! The bands are visible as far as the blue; large, but not very deep. On Jan. 13, 1882, the star was 7·5 mag.

275. *Pechüle;* 1883, Jan. 5, spect. feeble.

276. *Dunér;* III. ! The bands are large and visible as far as the blue, but they are not very deep.

277.

278. *Pechüle;* 1883, Jan. 6, spect. feeble.

279. 1888, Feb. 7, 7·8; reddish; II. (?); var. (?)—*Espin.*

280. *Vogel;* 1880, March 15, röthlich gelb; IV. (?) *Dunér;* jaune-rouge; III.; feebly developed. Bands 7 and 8 are best seen.

281. *D'Arrest* (A. N., 2044); fiery red; remarkable spectrum; normal fourth type. *Vogel* (Spect. Beob.); 1881, April 20, April 29, roth; IV. ! ! ! *Dunér;* rouge-jaune foncé; IV. ! ! !, with four zones, of which the ultra blue is exceedingly feeble, and very difficult to see. Bands 4 and 5 of the yellow sub-zone are well seen; perhaps also the rays 7 and 8. The principal bands are very large and very deep.

282. *Vogel* (Spect. Beob.); 1882, Feb. 12, gelb; II*a.*

283. 1888, Feb. 10, 8·0; orange; III. (?)—*Espin.*

284. 1888, Feb. 10, 8·7; pale yellowish red; III. ! bands obvious but not deep.—*Espin.*

285. 1888, Feb. 7, star 8 ± very red; great interruption from clouds; spectrum apparently IV.: Feb. 10, 8·0; wonderful colour; spectrum a mere fragment, and quite deficient at the violet end. I was not certain whether it was IV. type or III. with abnormally developed bands. Feb. 16, IV. type.—*Espin.*

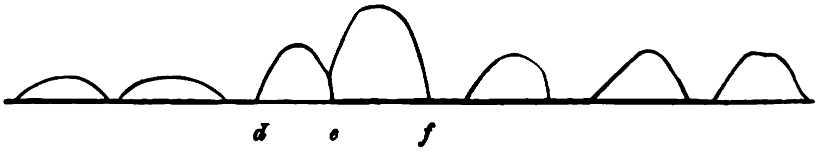
286.

287. *Pechüle;* 1886, Jan. 6, spectrum feeble.

No.

288. *Secchi;* golden red-yellow; rudiments of zones, and a strong line in the green, of magnesium.—*Mem.* II. Red; zones; fourth type (?).—*Prodromo*, &c., 1876. *Dunér;* examined twice; rouge-jaune. The spectrum is not at all iv., but perhaps iii. The star is too low to admit of certain judgment. *Pechüle;* 1886, Jan. 5, 4·5; orange; spect. cont.; iv. (?).

289. *Secchi;* March 20, 1868, wonderful spectrum: a perfect type of α Orionis, but so black at the dark lines that nothing remains but the bright lines of the third type. It seems, however, as if continuous to the yellow. After this there are three groups of bright lines, which one might take for those of a nebula. Examined with a cylindrical lens, and power 200, the type of α Orionis appeared, but with very black zones; the zones are identical with α Orionis, especially *fe* and *de;* the bright lines are separated by spaces quite black.—*Mem.* II. May 11, 1869, the third type confirmed; the black near *b* seems more toward the red than the black of the fourth type.—*Sugli Spettri*, &c., Marzo, 1872. *Birmingham's note.* Dr. Ball has kindly sent me his observation of this spectrum, which he describes as "most remarkable. There are six or eight black bands in the red; two of them very strongly marked." This seems a striking instance illustrative of Secchi's remark (*Mem.* II., p. 11), that the naked-eye colour of a star may not indicate the superior development of that colour in the spectrum. *D'Arrest* (A. N., 2032); bright reddish; 7 mag.; often yellowish; spectrum, third type; nearly as decided as in α Herculis, β Pegasi, and similar stars. A slight variability may be suspected. *Dunér;* rouge-jaune; iii.!!! Bands 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 are excessively large and deep. The spectrum is totally discontinuous.



290. *Konkoly;* 1885, March 20, iii. ii*a*. *Espin;* 1888, Feb. 10, iii. (?) feebly-developed spectrum.

No.

291. *Konkoly;* 1885, March 11, III.; broad band in red.

292. *Dunér;* III.!! Bands 2, 3, 4, 5, 6, 7, 8, 9 are very large and deep: 2 and 3 are stronger than the others.

293. *D'Arrest* (A. N., 2044); bright orange; 7 mag.; spectrum III.; broad bands; a fine sharply-defined specimen. *Vogel* (Spect. Beob.); 1880, March 16, III.!! *Dunér;* jaune-rouge; III.!! On account of the feebleness of the star the spectrum has but little light; but in spite of this bands 2–9 appear very large, and strongly marked.

294. *Pechüle;* 1883, Jan. 6, spectrum feeble. *Dunér;* I have not found any star in the position indicated by Secchi, nor in the neighbourhood of 124 Schj. *Espin,* 1888, Feb. 10, not seen. The only red star I found here is D. M. – 21°. 2780; 8·7 mag. This star was estimated 8·0 red. It lies 2ˢ ± F., and 20′ ± N., the place of Secchi's star.

295. *Secchi;* solar type, with fine lines, as in Procyon and the Sun; magnesium, and probably sodium: April 14, 1869.—*Sugli Spettri,* &c., 1872. Yellow; third type; strong lines in the red, and as if truncated.—*Prodromo,* &c., 1876. (If there is no error, there seems a change of type here.) *Dunér;* II.!!; superb, and of most pure type; it approaches the solar type as much as that of Aldebaran. The rays are black, narrow, and not grouped. *Konkoly;* 1884, March 16, gelb; II*a*.

296. *Konkoly;* 1885, March 11, II*a*; type of *α* Tauri.

297. *Pechüle;* 1883, Jan. 6, spectrum feeble.

298. *Konkoly;* 1885, March 11, II. (?); only the green plainly visible.

299. *Vogel* (Bothkamp. Beob. I.); on account of the feeble light of the star, the spectrum has only a feeble extension. The deep bands resemble *α* Orionis in their intensity in the violet, and are rather sharply defined. *Dunér;* rouge-jaune foncé; III.!! I could not examine the star at its maximum, but nevertheless I have observed that the bands are very large and deep, especially in the blue.

300. *Secchi;* deep red; zones; feeble.—*Prodromo,* &c., 1876. *D'Arrest* (A. N., 2044); 1875, May 6, strikingly red; 8·6 mag. The hitherto unknown spectrum of this star belongs to type III., with broad,

No. 300—*continued.*

sharply-defined zones. *Vogel* (Spect. Beob.); 1880, April 5, red; estimated 9·8, III.!! *Dunér;* presque rouge absolu; III.!!! The bands 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 are extremely large and deep. The spectrum is as beautiful as that of Mira at the same magnitude. Between the bands 3 and 4 there is a sharp band. Band 4 is double.

301. *Dunér;* III. type. The bands 2, 3, 7 are undoubtedly visible, and perhaps 4 and 5. The development of the spectrum is feeble.

302. *Secchi;* curious spectrum, showing a near approach to the nebula spectra, with a strong green zone; the remainder indistinct: March 17, 1868. With better air, on March 22, was found, decidedly, a spectrum of the IV. type, except that, on account of the smallness of the star, the blue zone was not observed; and there was a lacuna in the red: strong cylindrical lens. In seeking this star Secchi found a small one, yellow, and type of α Orionis (*Mem.* II.). (This is No. 294; Birm., 222.) *Pechüle;* 1883, Jan. 5, IV. type; beautiful. *Dunér;* rouge-jaune foncé; very beautiful in spite of the small altitude of the star. It has three zones, of which the blue is rather feeble. The sub-zone yellow bands 4 and 5 are perfectly well seen, and the principal bands are very strong.

303.

304. *Pechüle;* 1883, Jan. 4, spectrum IV. type.

305. *Pechüle;* 1883, Jan. 6, spectrum IV. type.

306. *Secchi;* bright orange red, but no distinct lines, and spectrum misty and feeble; remarkable, however, on this account; perhaps slightly variable. It is preceded at a little distance by a star of the type of α Lyræ: March, 1868.—*Mem.* II. Variable; zone spectrum.—*Prodromo,* &c., 1876. *Konkoly;* 1884, March 15, gelblich weiss; II*a.*

307. *Pechüle;* 1883, Jan. 3, spectrum IV. type.

308. *Pechüle;* 1883, Jan. 6, spectrum appears continuous.

309.

310.

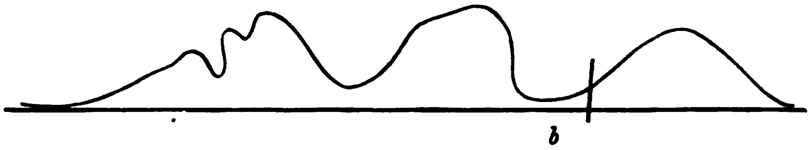
311. *Pickering* (A. N., 2376); IV. type. *Pechüle;* 1883, Jan. 3, IV. type.

312.

313. *Pechüle;* 1883, Jan. 3, spectrum continuous.

No.

314. *Secchi;* iv. type; well decided, with two strong bright lines in the yellow, which are to be measured to see if they belong to sodium: March 22, 1868.—*Mem.* II. On April 8, 1869, the iv. type was again quite decided; on May 11, observed again. The two bright yellow lines are certainly not those of sodium. They were compared with the sodium lines of α Orionis, with which they do not correspond at all. April 14, the yellow lines are certainly not those of sodium, while they are so in α Orionis; the black of magnesium corresponds well in the two stars.—*Sugli Spettri*, &c., Marzo, 1872. (It is remarkable that, in 1868, using a cylindrical lens, Secchi found the characteristics of the iv. type, while with a small spherical lens all these disappeared, and the spectrum appeared to belong to the third—a fact, apparently, of no small significance.) *Dunér;* rouge-jaune foncé; iv.!!!; of extraordinary beauty, with four zones. Band 6 is not very deep, but, for the rest, all the bands and rays, 1–10, are strongly developed. *Konkoly;* 1884, April 20, röthlich gelb; iii. type. *Espin;* the star has been observed several times in 1887–88, and always found to be iv. type. Dr. Konkoly speaks of the night as "Dunsterfüllt und unruhig," which may account for the mistake in type.



315. 1888, March 10, not found. Var. (?)—*Espin.*

316. *Konkoly;* 1884, April 20, 7·5; gelblich weiss; ii*a*(?) According to Ll., 6·5 mag.; strong H line.

317. *Dunér;* jaune-rouge; iii.!! The bands are large and deep throughout the spectrum, as far as 9, inclusive. The bands 7 and 8 are especially remarkable.

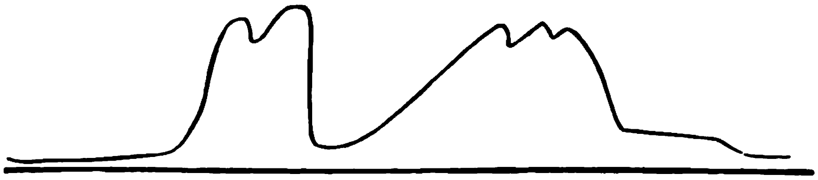
318. *Dunér;* rouge-jaune foncé; iv.!!!, with four zones, and with all the bands and rays 1–10. The principal band, 6, is considerably more feeble than 9 and 10. The yellow sub-zone is very sharp, and band 5 is strong. Bands 1, 2, 3 are more feeble; 7, 8 a little difficult to see.

No.

319. *Pechüle;* 1883, Jan. 3, spect. cont.

320. *Pechüle;* 1883, Jan. 3, spectrum very feeble.

321. *Secchi;* spectrum analogous to that of Schj. 132, but partly different; a fine double line in the yellow, followed by a dark zone; then bright green with a strong line in the middle; the blue wanting; appears as if a nebula spectrum. Lines apparently in the green. Difficult to say whether it belongs to the IV. type or not. Deserves study and measuring.—*Mem.* II. *Dunér;* presque rouge-absolu; IV.!! The principal zones, yellow, red, and green, are very brilliant, and separated by a band large and black; the bands 4 and 5 of the yellow sub-zone are also perfectly well seen. Once I succeeded in glimpsing an exceeding feeble trace of the blue zone.



322. *D'Arrest* (A. N., 2044); farblos; 7 mag. Spectrum, well marked columns dark and broad through all the colours; type III. *Vogel* (Spect. Beob.); 1882, Feb. 21, III.!!! *Dunér;* jaune-rouge; III.!!! The bands 2–9 are very large and deep. The development of the spectrum is superb.

323. *Secchi;* type of *a* Orionis, but very feeble. It is curious how, in this part of the heavens, are found so many Red Stars with strange type of spectra; colour pale red: March 22, 1868.—*Mem.* II. *Dunér;* jaune-rouge; III. type, pretty sure, but very feebly marked.

324. *Secchi;* distinct lines, but spectrum difficult on account of the proximity of *a* Crateris. Secchi remarked the variability of this star: April 21, 1868.—*Mem.* II. Full scarlet; zones.—*Prodromo,* &c., 1876. *Dunér;* presque rouge-absolu; III.!!, with the bands very deep, and excessively large in the bluish green. At the beginning, I observed the spectrum near the star's minimum, and took it for IV. type. In 1883 I recognized its true nature. *Espin;* III.!!!; very deep bands; several obs.

No.

325. 1888, March 10, 9·5; too faint.—*Espin.*

326, 327, 328, 329.

330. *Konkoly;* 1884, April 20, II*a*; like α Tauri.

331.

332. *Secchi;* rose colour; 8 mag.; spectrum diffused, and continuous.—*Mem.* II.

333. 1888, April 13, II. III.; uncertain; misty.—*Espin.*

334.

335. *Pechüle;* 1883, Jan. 5, spect. cont.

336. 1887, March 23, III.!!!, very deep bands.—*Espin.*

337. *Vogel* (Spect. Beob.); 1880, April 13, röthlich gelb; III. type. *Espin;* 1887, March 27, III. type. (?)

338. 1888, May 5, too faint; a 7·0 near, pale orange red, is probably III. type.—*Espin.*

339. *Konkoly;* 1885, May 6, III.!

340.

341. 1888, April 11, red; 10 mag.; bands; probably III. type.—*Espin.*

342. *Dunér;* rouge-jaune, III.! The bands are large and deep throughout the spectrum, but especially in the bluish-green.

343. *Dunér;* rouge-jaune, III.! The bands are large in all the colours. The spectrum resembles perfectly the neighbouring spectrum of R Corvi.

344. *Ellery* (M. N., XLIX., No. 9, p. 440); continuous spectrum.

345, 346.

347. *Vogel* (Spec. Beob.); 1881, April 16, gelblich weiss, I*a*.

348, 349.

350. *Secchi;* type IV.; lines broader in the red than in the violet.—*Prodromo,* &c., 1876. *D'Arrest* (A. N., 2044); 8 mag., with highly interesting spectrum of the IV. type requiring special study; it is so bright that it can be observed in moonlight; consists almost entirely of red and yellow rays: ceases abruptly in the green; and all more refrangible rays totally absorbed—a fragment of a star spectrum! Bessel, in 1823, first remarked the striking colour of the star. *Vogel* (Spect. Beob.); 1881, March 31, red; IV.!!! *Vogel* (Pub. 14). In the spectrum of this star five bands are seen—two in the red and

No. 350—*continued.*

orange—of which the last is most intense; one band in the bright green, the darkest in the whole spectrum; one band in the dark green, one in the blue. In favourable moments there appears also the isolated dark line in the yellow. *Dunér;* rouge-jaune foncé; IV.!!, with three zones, of which the blue is rather feeble. The yellow sub-zone, and the bands 4 and 5 are perfectly visible, and perhaps also the bands 2 and 3. It is singular that D'Arrest was not able to perceive the blue zone. At Vienna, Vogel has also seen the ultra-blue zone.

351, 352.

353. *Ellery* (M. N., XLIX., No. 9, p. 440); spectrum with flutings fading away gradually towards red end. Two of these are in the red, very intense; one in the yellow, rather faint. Three in the blue, very prominent, and one somewhat faint in the green. Fine dark lines in the violet. Flutings easily resolved into dark lines grouped closer and closer together towards the violet end of the spectrum, where they terminate abruptly.

354. *Dunér;* jaune-rouge; III. The bands are not deep but large, and visible as far as the blue.

355. *Secchi;* Prodromo, &c., 1876; diffused spectrum. *Vogel* (Spect. Beob.). 1881, April 19, 10 mag.; gelblich roth; IV. (?) *Dunér;* jaune-rouge; III.! The bands are visible, apparently as far as 9 inclusive. They are large, but so pale that it is difficult to count them with certainty.

356.

357. 1888, Jan. 26, 28, III.!!! The bands are of extraordinary depth and intensity.—*Espin.*

358. 1887, March 27, spect. cont.—*Espin.*

359. *Konkoly;* 1885, May 12, III. II*a*.

360.

361. 1887, March 27, III. (?).—*Espin.*

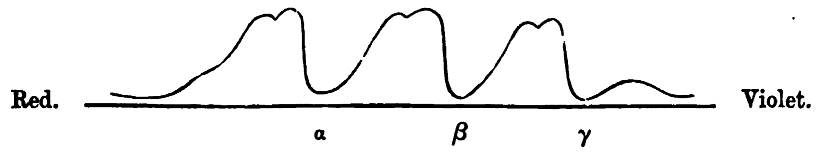
362. 1887, March 27, III. (?).—*Espin.*

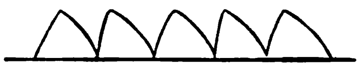
363. *Dunér;* rouge-jaune, III., but very feebly developed.

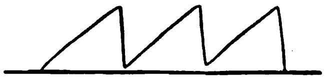
364. *Secchi* (*la superba*); magnificent object of the IV. type, and truly

No. 364—*continued.*

remarkable for the vivacity of its light. It exhibits three broad, bright zones—one yellow, another green, and the third blue; all sharply defined towards the violet, and hazy on the side of the red. The zones have bright lines at the edges: March 21, 1868. In the yellow those lines are like two threads of gold—two in the green and the blue, which is not so bright. There are minor striæ: April 22.—*Mem.* II. In 1869 Secchi made a series of observations of this star. He found a coincidence in the carbon lines and a gaseous spectrum. The D line of sodium did not correspond at all with the dark line in the yellow—magnesium appeared doubtful—but, on the whole, one conclusion seemed certain: that in this, and all stars of the IV. type, carbon existed in a certain combination with hydrogen, and that a similar, or nearly similar, combination is found in stars of the third type as well. Carbonic oxide (CO) was also indicated by the spectrum of No. 152.—*Sugli Spettri*, &c., Marzo, 1872. In his notes on this star Secchi remarks, as characteristic differences between the III. and IV. types, that the light curves incline in opposite directions—in the former towards the red, and in the latter, with broader zones, towards the violet, thus:—



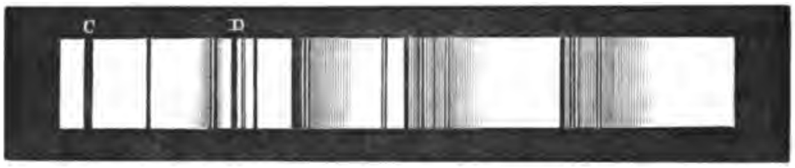

Third Type.


Fourth Type.

This notably distinguishes the types. There is some analogy between this spectrum and that of the comets.—*Mem.* II. Another important fact noted here by Secchi relates to the modifications of spectra according to temperature. For instance, the columnar spectrum of benzine is changed into a line spectrum by an increase of heat. It is indeed curious how those spectra become altered with

No. 364—*continued.*

every variation of incandescence.—*Sugli Spettri*, &c., Marzo, 1872. Birmingham, in a foot note, adds: "Huggins widely differs from Secchi in his account of this star. In a note to the English translation of Schellen's *Spectrum Analysis*, edited by Dr. Huggins, p. 504, I find the following:—'The description of the spectra of these stars differs from the appearance they present to the editor. He places below a diagram of the spectrum of the Red Star, Schj., No. 152. He compared the spectrum of this star, using a narrow slit, with the brightness of sodium and carbon. The line marked D he found to be coincident with that of sodium. The less refrangible boundary of the first of the three principal bright bands in the spectrum of carbon is nearly coincident with the beginning of the first group of dark lines; the second of the carbon bands is less refrangible than the second group in the star; the third band of the carbon spectrum falls on the bright space between the second and third group of dark lines in the spectrum of the star. The absorption bands are therefore not due to carbon. There is a strong line about the position of C, but this part of the spectrum is too faint to admit of comparison or microscopic measurement. The comparative relative freedom of the red part of the spectrum from dark lines is in accordance with the predominance of this colour in the star's light.'" *Dunér;* rouge-jaune foncé; IV.!!!, with four zones of an extraordinary vivacity, separated by bands excessively large and black. The bands 3, 4, and 5 are very well seen, and also the bands 1, 2, 7, and 8, but they are feeble.



365. *Pechüle;* 1883, Jan. 6, spect. cont.
366. *Konkoly;* 1885, May 12, III. II*a*.
367.
368. *Vogel;* 1881, April 19, 8·4; röthlich gelb; III.!!

No.

369. *Vogel;* 1882, March 17, gelb; II*a*.

370, 371.

372. *Konkoly;* 1885, May 12, II*a*.

373. *Konkoly;* 1885, May 12, III.

374. *Secchi;* deep red; type IV.; very bright zones separated by very black zones.—*Prodromo*, &c., 1876. *D'Arrest* (A. N., 2009); strikingly reddish; 7 mag. This peculiarly remarkable spectrum consisting of brilliant light lines separated by broad, dark intervals, demands special study. Secchi's IV. type. Birmingham adds: " Dr. Ball has sent me his observations of this spectrum, which he describes as ' remarkable.' The black bands terminate abruptly towards the red, and are shaded off towards the blue end." *Dunér;* rouge-jaune foncé; IV. ! ! !, with three zones. The principal bands are very large. Bands 4 and 5 are well seen; 1, 2, and 3 very feeble. What renders the spectrum unique is, that the less refrangible part of the yellow sub-zone is considerably more feeble than the other.

375. 1888, April 6, 8·4; reddish; III. (?).—*Espin.*

376. *Konkoly;* 1884, May 14, IV. type. *Espin;* 1888, April 17, spectrum apparently continuous.

377.

378. *D'Arrest* (A. N., 2032); star, 7 mag.; in colour not differing from neighbouring stars, yet the spectrum is discontinuous, being a well-marked III. type. *Dunér;* III. ! ! Bands 2–9 are large and obscure.

379. *Konkoly;* 1884, May 21, II*a* III.

380. 1888, April 17, 10·0 mag.; bands suspected; III. (?); star too faint.—*Espin.*

381. 1888, April 17, 9·5 mag.; doubtful; bands probably glimpsed; III. (?) —*Espin.*

382. *Secchi;* April 21, 1868, red; 7; spectrum type of α Orionis; nebulous zones absolutely black. The vivacity of some lines is extraordinary. What an enormous absorption there must be!—*Mem.* II. May 11, 1869, III. type; 6 mag.; superb. In the yellow the zones are little separated, and are not very distinct from the magnesium to the red; some lines most vivid.—*Sugli Spettri*, &c., Marzo, 1872. Second type; superb; spectrum variable.—*Prodromo*, &c., 1876. *Dunér;*

No. 382—*continued.*

rouge-jaune foncé; III.!!!, of a beauty altogether extraordinary; only the spectrum of *o* Ceti (Mira) equal to it. Bands 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 are extremely large and perfectly black.

383. *Secchi;* bright red; spectrum faint and diffused.—*Prodromo,* &c., 1876. *Espin;* 1887, April 11, 7·0 mag.; red; III.!! type: May 3, 8·0; pale red; strong bands in blue end.

384. *Konkoly;* 1884, May 20, III. (?)

385. *D'Arrest* (A. N., 2009); star colourless, with very beautiful columnar spectrum. *Dunér;* jaune-rouge; III.!! Bands 2, 3, 4, 5, 6, 7, 8 are well marked, but a little narrow; 2 and 3 are the largest. *Espin;* 1888, Jan. 26, fine orange; III.!!!, but bands not deep.

386.

387. *Konkoly;* 1884, May 20, III. II*a*; feeble example.

388. *Pickering;* III. type. (?) *Espin;* 1887, April 23, 27, never could be sure whether III. or IV.; star too low for me.

389. *Dunér;* rouge-jaune; III.!! Bands very large and deep, especially in the green and in the blue. The star is 8·4, and there are occasions on which I have seen it 8·0 at least. It is perhaps variable.

390, 391, 392.

393. *Konkoly;* 1884, May 20, III.

394, 395.

396. *Konkoly;* 1884, May 22, III. II*a*.

397. *Konkoly;* 1884, May 20, III.; feeble example.

398.

399. *D'Arrest* (A. N., 2009); reddish yellow; 5·6 mag.; rather narrow, but very distinct bands in all colours as far as the blue. III. type. *Dunér;* III.! The bands 2–8 are visible; 2 and 3 are rather strong but not large; 7 and 8 are more feeble and narrow; 4 and 5 are only rays.

400. *Secchi;* yellow; spectrum uniform; nebulous indications. 1886, April 21.—*Mem.* II. *Vogel* (Spect. Beob.); 1881, May 16, gelb; II*a*.

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* For the subsequent discovery of bright lines in this star's spectrum see section on "Stars with Bright Lines in their Spectra."

No.

401. 1887, April 28, III. ! !—*Espin.*

402. *D'Arrest* (A. N., 2032); red, like a dimly-glowing coal; 8·2 mag. The difficult spectrum is evidently type III., and not, as one might expect, of type IV. Dr. Vogel has already seen dark bands in it.—*Vogel* (Pub. 14, 1883). The spectrum is conspicuous through its wide dark absorption bands; of these seven appear particularly intense. Altogether I am able to perceive ten bands in the spectrum. *Dunér ;* rouge-jaune foncé ; III. ! ! ! ; in spite of the feebleness of the star, the bands are very well marked, and of an extraordinary size through the whole spectrum.

403. *Konkoly ;* 1884, May 20, II*a*, like *a* Tauri.

404. 1888, April 17, III. (?) Bands suspected, especially in the blue.—*Espin.*

405. *Dunér ;* III. ! ! The bands are very large and deep as far as the blue. In spite of the feeble light, the marked characteristics of the spectrum are well seen.

406. *Dunér ;* rouge-jaune foncé ; III. The bands are certainly visible ; rather large, but pale.

407. 1888, April 17, III. (?) ; feeble bands suspected.—*Espin.*

408.

409. *Secchi ;* pale red ; 6½ mag. ; zone spectrum ; April 23, 1868.—*Mem.* II. *Dunér ;* jaune ; II*a*. The rays D and *b* are visible ; *b* is very large.

410. *Dunér ;* jaune-rouge ; III ! ! feeble, but strongly marked. The bands in the blue and in the green are extremely large and deep.

411. 1887, Feb. 26, III. ! ! ! : April 28, III. ! ! ! Bands remarkably broad and deep. 1888, April 11, III. ! ! ! Bands of extraordinary breadth and depth.—*Espin.*

412. 1887, April 23, spectrum apparently continuous.—*Espin.*

413. *Konkoly ;* 1884, May 24, II*a* III.

414. 1887, Feb. 26, III. ! ! : April 28, III. ! ! ! ; strongly-marked bands.—*Espin.*

415. 1888, April 17, too low.—*Espin.*

416. *D'Arrest* (A. N., 2032) ; magnificent columns in normal III.-type form. The bands broad, very dark, and partially falling off throughout the whole prismatic image. *Vogel* (Spect. Beob.) ; 1881, May 21,

No. 416—*continued.*

III. ! ! ! *Dunér;* III. ! ! ! The bands 1, 2, 3, 4, 5, 6, 7, 8, 9 are superb, large, and deep in all the colours of the spectrum.

417, 418.

419. 1887, April 23, III. ! ! !; fine spectrum; bands very deep: May 13, III. ! ! !; fine spectrum.—*Espin.* *Konkoly;* 1884, May 17, gelb; 8; III. (?)

420. *Secchi;* type III., like β Pegasi.—*Prodromo,* &c., 1876. *D'Arrest* (A. N., 2009); star 5 mag., with splendid band spectrum of the III. type, like β Pegasi. Remarkable on account of the colourlessness of the star; yet on four subsequent nights this star was a somewhat striking yellow. *Dunér;* rouge-jaune, III. ! ! ! The bands 1, 2, 3, 4, 5, 6, 7, 8, 9 are very large and very deep. The spectrum recalls rather that of α Herculis than that of β Pegasi; the bands are more marked than in the latter.

421. 1887, April 27, spect. apparently cont.: star low.—*Espin.*

422.

423. *Konkoly;* 1885, May 10, II*a.*; type of α Tauri.

424. *Dunér;* III. The bands are pale but visible as far as in the blue.

425. *D'Arrest* (A. N., 2044); star 6·7, without conspicuous colour. In spite of which the spectrum is so well developed that the superb image resembles that of α or g Herculis. *Vogel* (Spect. Beob.); 1881, May 23, gelb; III. ! ! ! *Dunér;* rouge-jaune; III. !, with the bands 2–8, and probably also 9 visible. The bands in the red are deep; the others are not strongly developed. The spectrum is fine, but in no way recalls the magnificent spectra of α and g Herculis.

426, 427, 428.

429. *Dunér;* III. ! The bands are very large, and well visible in all the colours, especially in the bluish-green.

430.

431. *Vogel* (Spect. Beob.); 1881, May 28, 11·0 mag.; roth; IV. (?)—*Espin.* 1888, April 17, 8·5; red; III. ! ! !; fine spectrum.

432. *Dunér;* rouge-jaune; III. ! ! Bands 2–9 are visible; they are deep and excessively large; 4 and 5 are considerably larger than is usual. My estimations of colour present remarkable differences. In 1878

No. 432—*continued.*

(May 5, 22, June 5), jaune-rouge; in 1880 (May 25), rouge-jaune; in 1882 (April 10 and 17), rouge-jaune foncé; in 1884 (April 27), the same, but deeper.

433.

434. Tried to see the spectrum on several occasions, but the star always too faint to see details.—*Espin.*

435. *Secchi;* third type, with narrow zones, like *a* Orionis. The star in the finder of the telescope, bright red and 6 mag. Schj. gives it 7½, and it therefore must be variable; magnesium zone certain, compared with Arcturus.—*Mem.* II. Confirmed type three; in the yellow the column decided and sharp (*Sugli Spettri*). *Vogel* (Spect. Beob.); 1881, May 23, gelblich roth; III.!!! *Dunér;* rouge-jaune; III.!! The bands are large and strong, especially in the green and blue. *Espin;* 1888, April 17, III.!!!; fine spectrum; the blue and green faint.

436.

437. 1887, May 9, too faint.—*Espin.*

438. *Secchi;* reddish; diffused spectrum.—*Prodromo,* 1876. *Espin;* I examined this star several times in 1887 very carefully, and found it yellowish white, and spectrum continuous.

439. *Dunér;* rouge-jaune foncé; IV., with three zones feebly developed. Band 9 is strong, but band 6 is rather feeble. The secondary bands are not visible.

440. *Vogel* (A. N., 2000); max., March 26; observed on April 7; colour yellow red; fine spectrum, with several bands; blue and violet were, in comparison to other stars of III. type, remarkably visible, with many dark bands; spectrum proved by measurements to resemble *a* Herculis. *Vogel* (Spect. Beob.); 1881, May 24, röthlich gelb; 9·0 mag.; III. (IV.). *Dunér;* rouge jaune; III.!!; very beautiful; the bands in the blue are so large that they make the spectrum entirely discontinuous; magnitude only 7.

441. 1888, April 17, too faint.—*Espin.*

442.

443. 1888, April 17, bands seem large; perhaps IV.—*Espin.*

No.

444. 1888, April 17, III. (?).—***Espin.***

445. ***Konkoly;*** 1885, June 8, III.; feeble example.

446. 1887, March 27, April 14, III. ! ! ! In spite of the feebleness of the star the spectrum is quite pronounced, the bands being very large and deep.—***Espin.***

447. 1888, May 8, 10·5; too faint.—***Espin.***

448. *Secchi;* pale red of the magnesium type—that is to say, a strong green line near the magnesium; a bad observation; July 9, 1868.—***Mem.*** II. *Espin;* 1888, May 8, slightly orange red; II. (?)

449. *Vogel* (Spect. Beob.); 1881, May 31, gelb; II*a*.

450, 451, 452, 453, 454, 455, 456.

457. *Dunér;* presque rouge absolu; IV. ! !; with 3 zones. The yellow, red, and green zones are brilliant, and separated by a large lacuna. As for the blue zone it is excessively feeble, and, in 1878 and 1882, I could not see it.

458. *Vogel* (A. N., 2000); max., April 3; observed May 4; a handsome red star, 7·5 magnitude, exhibiting a peculiarly well developed band spectrum, especially in the green. *Dunér;* rouge-jaune foncé; III. ! ! Bands 2–9 are very large and deep, especially 8.

459. *D'Arrest* (A. N., 2044); 6 mag.; gelblich; beautiful columns; bands broad and very deep, in normal grouping. *Dunér;* rouge-jaune; III. !; beautiful. Bands 2–8 are well marked; 2 and 3 are very large and deep.

460. *Konkoly;* 1886, July 2, spect. cont.

461. *D'Arrest* (A. N., 2044); spectrum extremely brilliant, and magnificent example of type III.; very like β Pegasi, and little inferior. Bands dark and broad throughout. *Dunér;* III. ! ! !, quite like α Herculis. Band 6 is a little feeble, but the other bands, 2–9, are excessively large and black.

462.

463. *Dunér;* rouge-jaune; III. ! The bands are strongly developed as far as in the ultra-blue, but feeble in the red.

464. *Pickering;* banded spectrum.

465.

No.

466.

467. *D'Arrest* (A. N., 2044); 7·8; gelblich; spectrum III., like an imitation of 42 Herculis with well separated bands. *Dunér;* rouge-jaune; III.!!! Bands 2–8 are rather large and deep. Spectrum well developed.

468. *D'Arrest* (A. N., 2009); sehr gelb; splendid III.-type columnar spectrum. *Dunér;* rouge-jaune, III.!! Bands 2–8 are well marked; The spectrum perfectly resembles the preceding.

469. *D'Arrest* (A. N., 2009); fine columnar; a companion star of the great Hercules nebula, which itself shows an immense number of fine continuous spectra. *Duner;* rouge-jaune, II *a*. (??) There are, perhaps, in the spectrum two or three rays very pale and difficult to see, but no trace of bands. I have examined not only this star, but also all the other stars which are found in the neighbourhood of the great Hercules cluster (1884, April 27; '82, April 10, May 11, 18, 21; '80, May 12, 13; '82, April 1). See also Dunér's very interesting statement, p. 130, *Sur les étoiles*, &c. There seems little doubt of a change from a lower to a higher form here.

470.

471. *D'Arrest* (A. N., 2009); splendid specimen of the III. class (type?); zones separated by dark intervals; as easy as α Herculis. *Dunér;* jaune-rouge; III.!! Bands 2–9 are large and deep, especially 2 and 3, yet the spectrum does not equal 367 Birm.

472.

473. 1888, May 4, mag. 8.8; pale red; III. type, pretty sure, but star low and tremulous.—*Espin.*

474. *Vogel* (A. N., 2000); max., March 14; observed on May 4; colour, between red and orange; magnitude, 6·8–7; a fine band spectrum; the band ending with the *b* lines was particularly remarkable; the red not comparatively very brilliant. *Dunér;* rouge-jaune; III.! The spectrum is well marked but not very brilliant. The bands are large. Those in the green and blue the most marked.

475.

476. 1887, March 27, spectrum continuous.—*Espin.*

No.

477, 478, 479, 480.

481. *Vogel* (V. J. Schr., 16 Jahrg., p. 243); III. *Dunér;* rouge-jaune; III.!! The bands 2–9 are visible; 7 and 8 especially are strongly marked.

482.

483. *Konkoly;* 1886, June 21, II*a*, III.

484.

485. 1888, May 8, neighbouring star interferes with spectrum.—*Espin.*

486. *D'Arrest* (A. N., 2044); most brilliant spectrum of type III. Numerous and very dark bands throughout. *Vogel* (Spect. Beob.); 1881, June 18, röthlich gelb.; III.!! *Dunér;* jaune-rouge; III.!!!; superb because of its light. Bands 2–9 are all large. Those in the blue are real lacunæ.

487.

488. *Secchi;* rose colour; a strong zone in the green: July 10, 1868.—*Mem.* II.

489. 1888, May 4, III. (?) Doubtful; star too low.—*Espin.*

490. *Vogel* (Spect. Beob.); 1881, July 22, III.!! *Dunér;* jaune-rouge; III.!! Bands 2–9 are exceedingly large and very deep, especially those in the red, but 4 and 5 are also larger than usual.

491.

492. *Dunér;* presque rouge absolu; IV.! with three zones, of which the blue is scarcely perceptible. The two others are separated by a band large and black. The yellow sub-zone seems like a bright band; but the bands 4 and 5 are not visible. *Espin;* 1888, May 4, IV.!!; very strong bands.

493.

494. *Dunér;* rouge-jaune; III.! The bands are very large and easily seen, especially 7 and 8.

495. *Vogel* (Spect. Beob.); 1881, July 17, III.!! *Dunér;* jaune-rouge; III.!! The bands 2–8 are visible; they are large and deep in the red and in the bluish green.

496.

497. 1887, March 27, III. (?).—*Espin.*

498, 499.

No.

500. *D'Arrest* (A. N., 2016); fine zone spectrum, but requiring good air; frequently observed. *Dunér;* jaune-rouge. Bands 2–8 were seen, but only with difficulty. 2 and 3 are the only ones easily seen. The nature of the spectrum is undoubted, but it is very feebly developed.

501. *Dunér;* iv., with 3 zones. The green zone is the most brilliant. The spectrum is rather fully developed. *Espin;* 1888, April 17, May 3, type iv., pretty certain, but low.

502. 1888, April 17, 8·3; very pale orange red. Spectrum does not seem continuous; probably iii.—*Espin.*

503. *Dunér;* iii.! Bands large and deep as far as the blue.

504. 1888, April 17, 7·8; orange; spect. continuous. (?)—*Espin.*

505.

506. *Vogel* (Spect. Beob.); 1881, June 20, gelb; ii*a*.

507.

508. *Vogel* (Spect. Beob.); 1881, July 22, iii.! *Dunér;* iii.; fully developed. Bands most easily seen in the green and in the blue.

509, 510, 511.

512. *Vogel* (Spect. Beob.); 1880, Aug. 4, iii.!! *Dunér;* iii.! The bands 2–8 are very well developed, especially those in the bluish green.

513. 1888, May 4, 8·0; pale red. Bands. (?) Spectrum doubtful in dawn. —*Espin.*

514. *Duner;* iii.!! In spite of the feebleness of the star the bands are very well seen as far as the ultra blue. They are so large and decided that the spectrum becomes quite discontinuous, especially in the bluish green and blue. *Espin;* 1887, April 2, found independently; iii.!!!

515. *Konkoly;* 1886, Aug. 2, ii*a*; type of α Tauri. *Espin;* 1889, Aug. 20, iii. type.

516. *Vogel* (Spect. Beob.); 1881, Aug. 24; ii*a*.

517. 1888, May 3, too faint.—*Espin.*

518, 519, 520.

521.

522. 1889, April 17, possibly iii.—*Espin.*

No.

523. 1889, Aug. 20, 8·5; red; large bands; believed III.; fine field.—*Espin.*

524.

525. *Konkoly;* 1886, Aug. 2, II*a.*

526. 1889, Aug. 20, believed to be III.—*Espin.*

527. 1889, Aug. 20, very red; 9·0; IV. (?).—*Espin.*

528. *Konkoly;* 1886, Aug. 2, III. II.

529, 530, 531.

532. *Secchi;* most beautiful red star, 7 mag., with columnar spectrum, July 16, 1868.—*Mem.* II. *See note in text of Catalogue.*

533. 1888, April 17, 5·0; orange; II. III.—*Espin.*

534. 1887, March 27; spectrum apparently continuous.—*Espin.*

535, 536, 537, 538, 539, 540.

541. *Vogel* (Spect. Beob.); 1880, Aug. 26, III.

542. *Secchi;* beautiful rose colour; spectrum like Arcturus, with strong lines, but no zones. *Espin;* 1888, April 17, III. (?); in dawn.

543. *Vogel* (Spect. Beob.); 1880, Aug. 26, röthlich gelb; III. *Espin;* 1888, May 8, 13, III.!

544. *Bm.'s note:* Secchi was not certain that he found this star, and thinks it must be variable. I have found it always *blue*, and suggested a variation in colour (see Catalogue). *Espin;* 1889, Sept. 20, III.

545. *Secchi;* intense red; faint zones.—*Prodromo*, &c., 1876. *Bm.'s note:* Dr. Ball, in a private letter to me, describes the star as vivid red; spectrum banded. *Dunér;* presque rouge absolu; IV.!, with three zones, of which the blue zone is exceedingly feeble. The principal bands are large and deep. Perhaps there is also a trace of band 4.

546. 1888, April 17, 8·0; spect. cont.—*Espin.*

547. *Vogel* (Spect. Beob.); 1880, Aug. 26, III.

548.

549. *Konkoly;* 1883, Aug. 2, 20, 6·5; weisse; I*a.* *Espin;* 1889, Sept. 20; III.

550.

551.

552. *Vogel* (Spect. Beob.); 1881, Aug. 25, röthlich gelb; II*a* (III.)

No.

553. 1887, March 23, and subsequent nights. Magnificent III.-type spectrum. The star reached mag. 6·5. 1889, Nov. 17, bright lines. —*Espin.* (See section on "Stars with Bright Lines in their Spectrum.")

554.

555. *D'Arrest* (A. N., 2009); 7 mag., with a surprisingly beautiful III.-type spectrum—one of the best marked of the type of α Herculis—similar to δ^2 and R Lyræ. *Dunér;* III.!!; very beautiful and well developed. Bands 2–8 are large and deep. *Espin;* 1886, Nov. 2, III.!!

556. *Konkoly;* 1886, Aug. 4, III.(?), very feeble. *Espin;* 1889, Aug. 20, III. (?)

557. 1889, Aug. 20, III.!!! Large and deep bands.—*Espin.*

558. 1887, March 27, bands (?) III. (?)—*Espin.*

559. Not seen.—*Espin.*

560. 1889, Sept. 20, III.—*Espin.*

561. *Secchi* (private letter to Mr. Birmingham); red colour certain; zones clear and well defined, though mag. only 8·5. *Dunér;* rouge-jaune foncé; IV.!!, with three zones. The two bands are strong and large.

562.

563. *Konkoly;* 1886, Aug. 4, II*a*; type of α Tauri.

564. 1888, April 17, 7·8; pale orange red; two companions; believed to be III. type.—*Espin.*

565. *Vogel* (Spect. Beob.); 1880, Aug. 26, roth; mag. 9·2; III.!

566. 1888, March 27, III. type.—*Espin.*

567. 1888, date doubtful; II. (?)—*Espin.*

568. *Vogel* (Spect. Beob.); 1881, Aug. 25, gelb; II*a*.

569.

570. *Dunér;* rouge-jaune foncé; IV.!!, with 3 zones. Bands 6 and 9 are very large and deep. Moreover, I see the yellow sub-zone with the bands 4 and 5, and very feebly, band 2.

571, 572, 573.

574. 1889, July 27, 8·0; white; spect. cont.—*Espin.*

575. *Vogel* (Spect. Beob.); 1881, Aug. 29, gelb; II*a*.

No.

576. 1887, Sept. 7, 15, 18, bands; probably IV. type.—*Espin.*

577. 1888, April 17, 8·4; orange; spectrum, at first thought to be continuous, afterwards suspected to be a weak III. type.—*Espin.*

578. *Vogel* (Spect. Beob.); 1881, Aug. 25; roth; IV.! *Dunér;* presque rouge absolu; IV.!, with 3 zones. The blue zone is exceeding feeble; the bands are strong.

579. *Dunér;* III.! The bands are large, but little opaque, throughout the entire spectrum to 9 inclusive.

580. *D'Arrest* (A. N., 2016); 7 mag.; type III.; well marked and easily seen. *Dunér;* III. The six ordinary bands seen, but they are rather pale.

581. *Vogel* (Spect. Beob.); 1880, Aug. 26, röthlich gelb; II*a*.

582.

583. 1889, July 27, 8·2; yellow; spect. cont.—*Espin.*

584. *Vogel* (A. N., 2000); fiery red; 7·8 magnitude; spectrum with four bands; a weak one in the red; a broader and stronger one in the yellow, becoming ill-defined towards the violet; a similar band in the green, and a very weak one in the blue. *Vogel* (*Berichte der Ges. der Wissensch. zu Leipzig*); the spectrum remarkable through its exceedingly small extension. The blue and violet are almost completely absorbed; only the green, yellow, and red are well seen. Both of the first-named colours are very much reduced through the rather sharp absorption bands limiting them; in the red a feeble band fading away. *Dunér;* presque rouge absolu; IV.!!, with three zones, of which the blue is exceedingly feeble. Bands 4 and 5 of the yellow sub-zone distinctly visible.

585.

586.

587. *Vogel* (Spect Beob.); 1880, Aug. 26, 9·6; roth; III. (?) *Dunér;* rouge-jaune foncé; III.!!; very fine in spite of the small light of the star. Bands very large and deep in all the colours.

588.

589. *Secchi;* rose colour; scarcely 8 mag.; July 15, 1868. Birmingham adds: "Secchi, in 1868, thought this star variable, as it is rated 7 mag. by previous observers. In August, 1869, he found it 5 mag., with

No. 589—*continued.*

uniform spectrum; bright in the yellow. It has certainly appeared to me variable (see observations in Catalogue). In the *Prodromo*, 1876, Secchi calls the zones variable." *Dunér;* rouge-jaune; spectrum uniform.

590. 1888, Aug. 13, 7·0; pale orange red; III. (?)—*Espin.*

591. *Konkoly;* 1883, Aug. 27, II*a*!; very fine lines.

592.

593. *Dunér;* rouge-jaune; III.!! The bands are extremely large and deep in the green and blue. In the red they are feeble.

594. *Vogel* (Spect. Beob.); 1881, Sept. 20, III. type.

595. 1888, Aug. 13, IV.!!!; fine spectrum.—*Espin.*

596.

597. *Dunér;* jaune-rouge; III.! The bands are visible throughout the spectrum. They are strongest in the green and blue.

598. *Vogel* (Spect. Beob.); 1881, Sept. 20, IV.! *Dunér;* rouge-jaune foncé; III.!! The bands in the bluish green are exceedingly large and deep. *Espin;* 1888, May 4, fine red; III.!!! Bands very large, but not very opaque.

599. *Dunér;* III.! Bands 2–9 are visible; they are rather large and well marked, especially in the green and blue.

600. 1887, March 23, III.!!!; fine spectrum; several obs.—*Espin.*

601. *Vogel* (Spect. Beob.); 1881, Sept. 20, röthlich gelb; II*a.*

602. 1890, Jan. 23, 7·8; orange red; III.—*Espin.*

603. 1888, Aug. 13, II. (?)—*Espin.*

604. *Vogel* (Spect. Beob.); 1880, Aug. 5, gelblich roth; III. type.

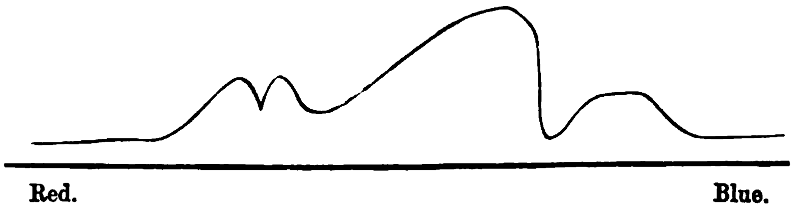
605. *Secchi;* fine star; 6 mag. at least; rose colour; very bright; spectrum like Arcturus with fine lines; strong black in the magnesium; bright green—may there be carbon? July 13, 1868.—*Mem.* II. Second type merging into third.—*Prodromo*, &c., 1876. *Konkoly*; 1883, Aug. 1 and 22, gelblich roth; II*a.*!

606. 1887, Dec. 7, spectrum apparently continuous, but images confused.—*Espin.*

607. *Secchi;* rose colour; 6·5 mag.; broad zones; IV. type: a broad zone terminating in the green; two lines in the yellow; the blue exceed-

No. 607—*continued.*

ingly faint; the red scarcely sensible: July 16, 1868.—***Mem.*** II. 1869, Oct. 5, no haziness, as in Schj. 152, but the zones sharply defined; bright fine lines in the yellow, like threads of gold; strong



magnesium.—***Sugli Spettri,*** &c., Marzo, 1872. Very red.—***Prodromo,*** &c., 1876. ***Dunér;*** rouge-jaune foncé; iv. ! ! !, with 4 zones. The principal bands are very large and black. Bands 2, 3, 4, 5, 8 are also visible, but very feeble. In spite of what Secchi says the red is very bright, although naturally a little pale in comparison with the yellow sub-zone.

608. 1886, Nov. 24, iv. ! !: Nov. 30, iv. ! ! !—***Espin.***

609. 1888, Aug. 13, not found; must be variable.—***Espin.***

610. *Vogel* (Spect. Beob.); 1881, Sept. 18, gelb; iii. (?) ***Dunér;*** rouge-jaune; iii. The bands 2, 3 are feeble; 7 and 8 well seen.

611. *Secchi;* rose colour; spectrum consists of one strong green zone commencing at the magnesium, and ending near the yellow; carbon (?): July 13, 1868.—***Mem.*** II. Remarkably red; bright zone in the green; iv. type (?).—***Prodromo,*** &c., 1876. ***Dunér;*** rouge-jaune; iv. ! !, with 3 zones. Bands 2, 3, 4, 5 are also visible.

612. 1888, Aug. 13: 1889, Aug. 20, apparently contin. spect.—***Espin.***

613. ***Dunér;*** rouge-jaune foncé; iii. ! The bands are not very dark, but they are large and visible as far as the blue.*

614. 1888, Aug. 13, spectrum apparently continuous.—***Espin.***

615. ***Dunér;*** rouge-jaune; iii. ! The bands in the blue are very large, and rather deep as far as band 9 inclusive.

616. ***Dunér;*** rouge-jaune foncé; iv. ! !, with 3 zones, of which the blue zone is rather brilliant. The principal bands are very strong and opaque, and the bands 4 and 5 are glimpsed.

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* See section on "Stars with Bright Lines in their Spectra."

No.

617. 1888, Aug. 13, III. (?) 1889, Aug. 20, III.—*Espin.*

618. *Vogel* (Spect. Beob.); 1881, Sept. 18, gelb; III.

619. *Vogel* (Spect. Beob); 1880, Aug. 29, röthlich gelb; III.

620. *Vogel* (Spect. Beob); 1881, Sept. 23, III.

621. 1887–88, several obs.; III. type (?).—*Espin.*

622. *Konkoly;* 1883, Aug. 27, II*a*!, like α Tauri.

623. Too faint; several trials.—*Espin.*

624. 1888, Aug. 13, suspected III. type, with feeble bands.—*Espin.*

625. 1888, Aug. 13, too faint.—*Espin.*

626. *Vogel* (V. J. Schr., Astr. Ges. Jahrg. 16, p. 243); spectrum III. type. *Dunér;* rouge-jaune; III.; feebly marked.

627. *Konkoly;* 1883, Aug. 27, II*a*.

628. *Secchi;* zones feeble, and most nebulous; magnesium distinct, July 13, 1868.—*Mem.* II. Red; III. type; feeble zones.—*Prodromo,* &c., 1876. *Dunér;* rouge-jaune foncé; III.!!! Bands 1–10, and also 6 are superb. Band 4 distinctly composed of two bands, pale, narrow, and very close. Also near 3 there is a ray, or rather a narrow band. Secchi is reported to have examined this star on July 23 (*sic.*), 1868, but in that year the maximum took place on March 15, and consequently the star was already, by June 3, below mag. 8, and at the time of Secchi's obs. between 9 and 10. It is evident that Secchi's observation, which does not agree with the real appearance of the spectrum, belongs to some other star (possibly Secchi observed χ^1 Σ. 2580, $4^m \pm$ p, 50′ n.). *Espin,* 1887, April 17, 7·0 mag. Red; III.!!!; superb.*

629. *Konkoly;* 1883, Aug. 27, III. (?) II*a*.

630. *D'Arrest* (A. N., 2009); in spite of the feebleness of the star—remarkable and uncommon—sharply defined columnar spectrum, obviously III. type. *Dunér;* III.! Bands 2–9 are well seen. Those in the green and blue are very large and strong.

631.

632.

633. *Konkoly;* 1883, Sept. 3, 4; III. II*a*; feeble bands.

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* See section on "Stars with Bright Lines in their Spectra."

No.

634. *Dunér;* rouge-jaune foncé, iv.!!, with 3 zones very strongly developed; blue zone very feeble, and band 6 larger than usual.

635.

636.

637. 1887, Dec. 7, 1888, May 13, believed to be banded, but spectra of the group confused; several attempts.—*Espin.*

638. Several obs.; bands suspected, always too faint.—*Espin.*

639. 1890, Jan. 23, 8·3; pale orange red; iii.

640. 1887, March 23, March 30, iii.!!!; bands broad, but not deep.—*Espin.*

641. 1887, Dec. 7, iii.!—*Espin.*

642.

643. 1886, Nov. 18, iv.!—*Espin.*

644.

645. *Secchi;* iii. type; distinct zones, notwithstanding the small magnitude. —*Prodromo*, &c., 1876.

646. Set for several times, but always too faint.—*Espin.*

647. 1890, Jan. 23, 8·0; orange red; iii. (?).—*Espin.*

648.

649. 1890, Jan. 23, 9·5; reddish; too faint for spectroscope.—*Espin.*

650. *Dunér;* rouge-jaune foncé, iv.!, with 3 zones, of which the green is the most brilliant, and the blue rather feeble. *Espin;* iv. type; several obs.

651. *Pickering* (A. N., 2376); type iv. *Dunér;* rouge-jaune foncé, iv.!!, with 3 zones, of which the green is the most brilliant. In spite of the feebleness of the star, the spectrum is strongly marked. The bands are all black, and of an extraordinary size.

652. *Pickering* (A. N., 2376); spectrum not peculiar.—*Espin;* several obs., apparently continuous.

653. *Vogel* (Spect. Beob.); 1880, Sept. 10, gelb; 9·2; iii. (?)

654. *Pickering* (A. N., 2376); type iv.

655. *Konkoly;* 1883, Aug. 26: Sept. 1, ii*a* iii.; transition to iii.

656.

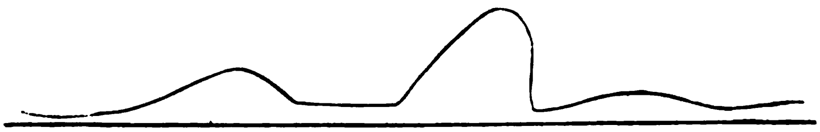
657. *Dunér;* rouge-jaune foncé; iv. After having many times examined

No. 657—*continued.*

this star's spectrum, I feel convinced that it is really IV. Band 9 is rather large and deep, but, besides this, I have not always seen other bands. In the best moment I have glimpsed a trace of bands 4 and 6. On Aug. 5, 1880, I believed I had perceived a trace of the ultra blue zone. The yellow sub-zone is more feeble than usual. The wave length of the edge of the strongest band is 519, and that of the limit of the visible spectrum 475. *Espin;* 1887, April 14, IV.!

658.

659. *Secchi;* deep red; 7·5 mag.; spectrum discontinuous, with only two zones in the yellow and in the green; IV. type certainly; near it is a small red star with continuous spectrum—one of Lalande's—July 15, 1868.—*Mem.* II. 1869, Sept., clearly IV. type; the green pretty strong; bright scintillations in the yellow; the blue exceedingly faint; 7 magnitude; air foggy. Secchi finds this star variable. —*Sugli Spettri,* &c., Marzo, 1872. *Dunér;* rouge jaune foncé, IV.!, with 3 zones. The blue zone is very feeble, but in spite of what Secchi says, the red is very well seen. The figure given by Secchi infers that he also saw band 5.



660. Repeatedly examined; 1886, '87, '88, but never showing any bands, and so continuous.—*Espin.*

661. *Vogel* (Spect. Beob.); 1881, Sept. 25, röthlich gelb; III. type.

662.

663. *Secchi;* deep red; zones doubtful.—*Prodromo,* &c., 1876. *Dunér;* presque rouge absolu, IV., with 3 zones rather feebly developed. Band 6 is feeble. *Espin;* several obs.; very feeble IV. type, remarkably poorly developed for so red a star. The star Bm. 535 is less red, but the bands are deeper. Baxendell ("Observatory," No. 125, p. 262) notes that the minimum magnitude which gradually fell from 9·4 in 1870, to 11·6 in 1880–'82, has since increased to 10·6, while the maximum magnitude has remained unchanged.

No.

664. 1887, April 2, iv., + 36°. 4025, not + 36°. 4028, as in A. N., 2788.—*Espin.*

665. 1887, April 2, iv. !—*Espin.*

666. Several obs., 1886, '87, '88. Bands of an extraordinary breadth and intensity; quite discontinuous; iii. type.—*Espin.*

667.

668.

669. *Vogel* (Spect. Beob.); 1880, Sept. 25, gelb; iii. (ii*a*).

670. Uncertain; possibly iii.; several obs. 1887, '88.—*Espin.*

671. *Secchi;* fine rose colour; spectrum continuous: July 16, 1868.—*Mem.* II. Continuous spectrum doubtful.—*Prodromo*, &c., 1876.

672. *Vogel* (Spect. Beob.); 1880, Sept. 11, iii. ! ! ! *Dunér;* rouge-jaune; iii. ! ! Bands 7, 8, 9 are exceedingly large and deep. The others rather narrow.

673. Several obs., 1886, '87, '88. iv. ! type.—*Espin.*

674. 1888, May 4, 7·0 mag; orange. Uncertain; ii. iii.—*Espin.*

675. *Vogel* (Spect. Beob.); 1881, Sept. 25; gelb; iii. type. (Vogel notes that there is a 9·4 mag., not in Argelander, 10 *s. p.* 1'5 *n.*, same colour and spectrum.)

676. *D'Arrest* (A. N., 2044); 6·7 mag.; hellgelblich; neat columnar spectrum. Bands very easily seen, especially in the red and orange. *Dunér;* rouge-jaune; iii. ! The spectrum is fairly marked, but the bands are neither large nor deep.

677. 1888, Aug. 31, iii. ! !—*Espin.*

678. *Vogel* (Spect. Beob.); 1881, Sept. 25, gelb; iii. (?)

679. *D'Arrest* (A. N., 2009); 7·8 mag.; very fine columnar spectrum of type iii.; remarkable dark bands continued in the violet. *Vogel* (Spect. Beob.); 1880, Sept. 11, iii. ! ! ! *Dunér;* iii. ! ! !; superb. Bands 2–9 are extremely large, and very black.

680. 1887, Oct. 15, 20, iv. type (?).—*Espin.*

681. *Vogel* (A. N., 2380). The spectrum is a beautiful example of type iv. Red and yellow include the half of the visible spectrum. The latter especially intense; blue exceedingly feeble; violet quite absorbed. *Duner;* presque rouge absolu; iv. ! Red and green zones brilliant;

No. 681—*continued.*

yellow sub-zone is very obvious, but I could see no trace of bands 4 and 5. Blue zone exceedingly feeble; scarcely visible. Band 6 is strong and large.

682. *Vogel* (Spect. Beob.); 1880, Sept. 11; röthlich gelb; III.!

683. 1888, Aug. 31, too faint.—*Espin.*

684. *D'Arrest* (A. N., 2016); Argel., 6·8 mag.; but in 1874, Sept. 10, only 8 mag., and remarkably red; band spectrum; well marked, and sharply defined for so faint a star; very dark intervals; *var.* (?): 1874, Sept. 10. *Vogel* (Spect. Beob.); 1880, Sept. 11, III.!! *Dunér;* III.!!! Bands 2–10 are extremely large and black, especially in the blue. Resembles, perfectly, D. M. + 17°. 4370 (Bm. 566).

685. *Konkoly;* 1883, Sept. 5; Oct. 28; II*a* (?) III.

686. *Dunér;* III.! The six ordinary bands are large and plain.

687. *Vogel* (A. N., 2000); beautiful clearly-marked band spectrum. *Dunér;* III.!! Bands 2–8 are very large and dark. *Konkoly;* 1883, Aug. 1, 31, III.!

688. Bands, probably IV.; several obs.—*Espin.*

689. *D'Arrest* (A. N., 2016); excellent columnar spectrum. The wide bands especially deep in the green and blue. Star 7 mag. *Vogel* (Spect. Beob.); 1881, Sept. 25, III.! *Dunér;* III.!!; very beautiful. Bands very obscure, and of an extraordinary size. Spectrum discontinuous in the green and blue. *Konkoly;* 1883, Oct. 30: Nov. 1, III.!

690. *D'Arrest* (A. N., 1969). The spectrum is the most remarkable of several thousands I have examined. *Vogel* (A. N., 2000). In spite of the feebleness of the star's spectrum, 10 deep bands are well seen. *Dunér;* III.!! Bands 2–10 are visible. Spectrum is discontinuous in the green and blue. Otherwise there is nothing exceptional in the spectrum.

691. 1888, Sept. 3, III.!!! Bands very deep and broad; mag. 8·7.—*Espin.*

692. Several obs.; spectrum continuous; bands sometimes suspected, but very doubtful.—*Espin.*

693. *Vogel* (Spect. Beob.); 1880, Sept. 14, gelblich roth; III.!! *Dunér;* jaune-rouge; III.!! Bands 2–8 are large, and deep as far as the blue. Bands 7 and 8 are the strongest.

No.

694. *Vogel* (Spect. Beob.); II*a*.

695. 1887, Oct. 17, III. (?).—*Espin.*

696. 1888, May 4, the blue and violet singularly faint, and the spectrum very unpronounced for so finely coloured a star, sometimes thought to be III., sometimes IV.; May 9, III.! type.—*Espin.*

697. *Vogel* (V. J. Schr., Astr. Ges. Jahrg. 16, p. 243). The spectrum is of the III. type. *Dunér;* jaune-rouge. The spectrum is excessively feeble, but undoubtedly III.

698.

699.

700. 1887, several obs.; III.!!! Bands of an extraordinary depth; spectrum totally discontinuous.—*Espin.*

701. *Vogel* (Spect. Beob.); 1881, Sept. 24, gelb; III. type.

702. 1888, Sept. 3, possibly III.—*Espin.*

703. *Secchi;* faint red; nothing remarkable in spectrum; near it are other red stars without anything remarkable in the spectra.—*Mem.* II. *Dunér;* rouge-jaune foncé; III. The bands are pale, but visible as far as the blue; in the red they are more feeble.

704.

705. *Dunér;* rouge-jaune foncé; IV. type. The nature of the spectrum is certain. There are three zones, of which the green is the most brilliant.

706. 1886, Nov. 30, bands (?). Examined subsequently on several occasions, but never sure whether it is III. or IV.; probably IV.—*Espin.*

707. *Secchi;* red; 9 mag.; IV. type, certain; must be variable: July 17, 1868.—*Mem.* II. 1890, Jan. 23, 10·7; red; too faint.—*Espin.*

708.

709. *D'Arrest* (A. N., 2044); 6·5 mag; subflava, with very splendid columnar spectrum; the bands especially broad in the more refrangible part. Type III. most beautiful specimen. *Dunér;* III.!!!, of an extraordinary beauty. Bands 1–9, and also 6, are distinctly visible, very large, and very black.

710. *Dunér;* presque rouge absolu; IV.!, with 2 zones: once I saw a trace, remarkably feeble, of the blue. Band 6 is rather large and obscure.

No.

711. *D'Arrest* (A. N., 2009); remarkably red; 6·7 mag.; peculiar spectrum of IV. type; some narrow bands in the red, but broad dark intervals in the green and blue, where the spectrum ends abruptly.—*Vogel* (1883); the spectrum is similar to Schj. 152. Only few differences in the relative intensity of the bands could be ascertained. *Dunér;* rouge-jaune foncé; IV.!!!, with 4 zones. Also, bands 2, 3, 4, and 5 of the yellow sub-zones and red are very distinctly visible. In the green zone, 7 and 8 are undoubtedly bands, and not rays. They are larger than in other spectra of this class. Dunér notes that Vogel's drawing shows that the secondary bands, 2, 3, 8, are stronger than in the spectrum of Schj. 152.

712. See section on "Stars with Bright Lines in their Spectra."

713. *Secchi;* strong red; 9 mag., like a drop of blood; IV. type, in which the blue is too feeble to be seen. Near it is a rose-coloured star with diffused spectrum. To the south is another with confused spectrum: July 17, 1868.—*Mem.* II. *Dunér;* presque rouge absolu, IV.! There are two brilliant zones, and feeble traces of the blue zone. The yellow sub-zone is somewhat strong, but I could not glimpse with certainty bands 4 and 5.

714. *Secchi;* July, 1868; red; 7 mag.; traces of thick lines, but undecided; air bad.—*Mem.* II. 1868, Dec. 9, fine red; 6 mag., and III. type; distinct columns; but the yellow zone is fully separated.—*Sugli Spettri*, &c., Marzo, 1872. *D'Arrest* (A. N., 2044); the spectrum belongs to the most perfect of type III.; the separating spaces are sharp, dark, and very broad. *Dunér;* rouge-jaune foncé; III.!! The bands 2–9 are very deep, but they are not very large.

715. 1890, Jan. 27, 9·5; red; one large band glimpsed, IV. (?).—*Espin.*

716. 1890, Jan. 27, not identified.—*Espin.*

717. *Konkoly;* 1883, Aug. 5, 6; II*a*.!; very broad lines.—*Espin;* 1886, Nov. 17, III.!! 1888, Sept. 3, Sept. 7, III.!!

718. *Secchi;* 1868, July15, magnificent red star of 5–6 mag., and III. type; columnar; superb; very bright lines.—*Mem.* II. 1869, Oct., bright

No. 718—*continued.*

in middle of spectrum, but faint toward the ends.—*Sugli Spettri*, &c., Marzo, 1872. *Dunér;* rouge-jaune; III.!! The spectrum is very beautiful; bands 2–9 are very large and obscure, but especially those in the blue.

719. *Vogel* (Spect. Beob.); 1881, Sept. 24, gelb; III. type.

720. *Dunér;* IV.!; zones red and green are separated by a band so large, that I have hardly seen its equal in any other spectrum. The blue zone is almost imperceptible.

721. 1887, Dec. 7, III.!!! The bands are very deep.—*Espin.*

722. *D'Arrest* (V. J. Sehr., Astr. Ges. Jahrg., 9, p. 285); spectrum; beautiful bands; III. type. *Dunér;* rouge-jaune; III.!! The spectrum very beautiful, and the bands 2–9 are opaque and very large, especially in the blue.

723.

724. *Konkoly;* 1883, Oct. 2; II*a* (III.); type of *α* Tauri.

725. 1887, Dec. 4, too faint; in moonlight. 1890, Jan. 23, 10 mag.; red; too faint.—*Espin.*

726. *Secchi;* 1868, Dec. 10; spectrum scarcely visible, but has zones; 9 mag.—*Sugli Spettri*, &c., Marzo, 1872. *Dunér;* 1878, Aug. 23, 1880, Aug. 5, spectrum uniform. *Espin;* 1887, Nov. 15, spectrum certainly not uniform; bands; probably III.

727.

728. On Jan. 17, 1868, Secchi found this star very small, and suggested its variability. On Dec. 9 he searched twice, and found that the largest star in the field of view was no more than 8 mag.—*Sugli Spettri*, &c., Marzo, 1872. See Catalogue. *Espin;* 1887, Dec. 4, III. (?); uncertain through moonlight.

729. 1890, Jan. 23. The only red star found here is D. M. + 57°. 2415 XXII.^{h} 15^{m} 56^{s} + 57°. 21′·6 (1890). This star is 9·2. Red, with bands which are large and obscure, but probably belong to III. type. —*Espin.*

No.
730. 1887, Nov. 15, not found.—*Espin.*

731. 1890, Jan. 23, 8·2; orange red; III.—*Espin.*

732. *Pechüle;* 1882, Dec. 7, III. type.

733. *Konkoly;* 1883, Sept. 1 : Oct. 6, III.!

734. *Vogel* (Spect. Beob.); 1881, Nov. 9, gelb; II*a.* (?)

735. 1887, Oct. 20, IV. type: Dec. 7, spectrum doubtful: Dec. 9, perhaps IV.—*Espin.*

736.

737. 1889, Oct. 17, spect. cont. Neither star red.—*Espin.*

738.

739. *Secchi*; spect. cont.—*Sugli Spettri.* Variable spectrum; certainly IV.—*Prodromo.* *Dunér;* hardly III., but not IV. *Pechüle;* 1882, Dec. 7, spect. cont.

740. *Vogel* (Spect. Beob.); 1881, Nov. 9, röthlich gelb; III. type.

741. 1888, Sept. 11, bands large and deep; probably III.; mag. 9·8.—*Espin.*

742. *Konkoly;* 1883, Sept. 3, 5; gelblich roth; II*a.*

743. 1887, Nov. 15, III. type.—*Espin.*

744. *Vogel* (Spect. Beob.); 1880, Sept, 28, mag. 9·0; gelb; III. type.

745. *Konkoly;* 1883, Sept. 3, 5, II*a* III.

746. 1887, Oct. 20, IV. (?).—*Espin.*

747. 1888, July 26, 8·5; yellow; bands. (?) 1890, Jan. 23, 8·5; pale orange red: III. (?).—*Espin.*

748. *Vogel* (Spect. Beob.); 1881, Nov. 16, röthlich gelb; III. type.

749. *Vogel* (Spect. Beob.); 1881, Nov. 16, röthlich gelb; II*a.*

750. *Secchi;* spectrum with faint zones. *Dunér;* jaune-rouge; III. (?) Once I was able to see bands 2, 3, 7, 8; and once, I suspected the presence of a band in the red and in the green. Two other times I could perceive nothing in the spectrum.

No.

751. *D'Arrest* (A. N., 2009); splendid band spectrum like *a* Herculis; many dark lines as far as the ultra blue region. One of the finest specimens of type III. *Dunér;* jaune-rouge; III.!! Bands 2–9 at least are visible. They are very strong and large. The spectrum is superb.

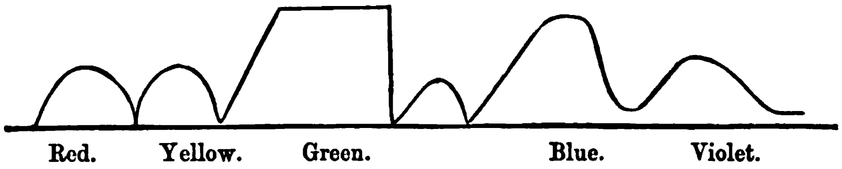
752. *Vogel* (Spect. Beob.); 1880, Sept. 28, III. type; very weak bands.

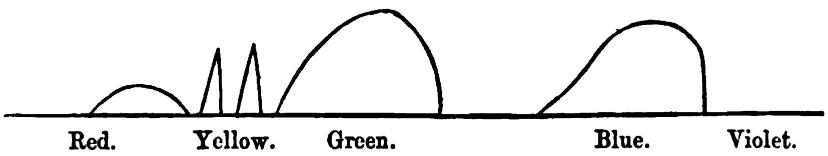
753. *D'Arrest;* gelblich; fine; very plain absorption bands, plainly visible in the red and orange. *Vogel* (Spect. Beob.); 1880, Sept. 28, gelb; III.! *Dunér;* rouge-jaune; III. The six ordinary bands are visible. Those in the red are very large; the others are narrow and not deep.

754. *Pechüle;* type III., with columns. *Dunér;* jaune-rouge; III.! The bands are visible in all the colours of the spectrum; they are large and deep.

755. 1889, Oct. 17, yellow; II. (?).—*Espin.*

756. *Secchi;* 1868, Jan. 17, excellent spectrum for measuring; seems intermediate between III. and IV.—*Mem.* II. In December the IV. type was confirmed, but the spectrum showed considerable differences.





In Oct., 1869, the IV. type was again decided.—*Sugli Spettri,* &c., Marzo, 1872. Type IV., but variable.—*Prodromo,* &c. *Vogel* (Spect. Beob.); 1881, Nov. 16, roth; IV.!!! *Dunér;* rouge-jaune foncé; IV.!!!; superb, with 4 zones. Bands 9 and 10 are very large and

No. 756—*continued.*

strong, but 6 relatively feeble. In addition, bands 1, 2, 3, 4, 5, 7, 8 are visible. Dunér finds that 5 is a band and not a ray. He also notes that his observations agree with the observations and drawings of Vogel in the *Ber. der Ges. der Wissen. zu Leipzig* (Dec. 12, 1873), and with those in *Publicationen*, &c., 14.

757.

758. *Vogel* (Spect. Beob.); 1881, Nov. 19, III. ! ! ! *Dunér;* jaune-rouge; III. ! ! The bands 2–8 are visible; 2 and 3 are very deep, and rather large. The others are well marked, but rather narrow.

759. *Vogel* (Spect. Beob.); 1881, Nov. 19, röthlich gelb; III. (?).

760.

761. 1888, July 26, III. ! ! !; violet very faint.—*Espin.*

762. *Pickering* (A. N., 2376); spectrum not peculiar.

763. *Vogel* (Spect. Beob.); 1881, Nov. 19, gelb; III. (?).

764. *Secchi* remarks the probable variability of the star; spectrum with exaggerated development in the green.—*Mem.* II. *Dunér;* presque rouge absolu; III. (?) In the yellow-red I undoubtedly see a band large and rather deep, but which only appears slightly shaded. This band is the strongest in the spectrum. Besides this, there is in the green another as large, but more feeble. With less certainty I see a band in the red, and one in the green-yellow, and very vaguely a band in the blue. The general character of the spectrum indicates that it is more like III. than IV. But it is not impossible that it may be an incomplete IV., after the same kind as Birm. 541, with bands 4 and 9 well seen, and 2 and 6 feebly glimpsed, or it may be an irregular spectrum of the III. type. *Espin;* 1886, Nov. 17, IV. type.

765. 1887, Sept. 19, IV. ! type.—*Espin.*

766. See note in the text of the Catalogue.

SOME DOUBTFUL STARS.

No.

144 = Birm. 112. This star was observed, 1888, Jan. 9, 10, and found to be white. A search was then made through Mr. Webb's MSS. in order to find the original observation, but no star was found. On Nov. 27, 1867, however, there is a note of a Red Star a little *n. p.* ω Orionis; and on Dec. 17 a fainter one, rather paler, was found a little *p. s.*, the same star. These were observed several times in subsequent years. At the end of an observation on Feb. 2, 1876, there is a note to the effect that, according to Sadler, it is P. V. 170 = Ll. 10646. There would seem to have been some mistake in identification. Mr. Webb's stars are:—

D. M. + 3°. 992,	V^h 32^m 40^s + 4°. 0′·6,	1890, mag.	8·8.
D. M. + 4°. 998,	V 33 11 + 4 . 4·6,	,, ,,	9·0.

150 = Birm. I., No. 23. 1888, Jan. 9, 10; my impression is that the star observed by Burton is D. M. + 31°. 1049, which lies 1^m 30^s·5 *p.* and 0° 2′·2 *n.* This star was observed by me on the following dates:—1886, Sept. 30, mag. 6·6; orange red; bands: Nov. 2, 7·0 mag.; III. type. 1888, Jan. 9, 7·8; orange red; III.! It is 6·6 in the D. M., and I believe variable.

— Birm. 118 = Schj. 63. R. A., V.^{h} 36^m 34^s + 2°. 18′·7. *Schj.'s notes:* "Schj., 1888; roth; 7·7. Ll. 10785; 8. Bessel; 889; 8." [*B.'s obs.:* blue; 7·3 in several obs.; and, Dr. Schjellerup, in a reply to a letter, informs me that he now finds it not red.: 1876, April 3.] Only one obs. of four at Dunsink made it any colour. A footnote (Dunsink Obs., IV., p. 47) suggests that the obs. probably belongs to Schj., 1880, = D. M. + 2°. 1036, which appeared reddish. This star lies *p.* 0^m 58^s·9, *s.* 0° 2′·1.

191 = Birm. 147. Mr. B. apparently observed two stars, this and H. P. 1189. (See Harvard College Obs., vol. XIV., II., p. 442.)

227 = Birm. 173 = Schj. 93. Schj.'s description of the colour would suggest that his note might belong to No. 230 = Es. 249.

228 = Birm. 174. This star is omitted from the fourth edition of C. O., and I have not been able to find any observation of it in Webb's MSS. A careful search was made, 1888, Feb. 13: the only red star found near here was No 232 = Birm. 176.

No.

294 = Birm. 222. Dunér (p. 88) states that he has not been able to find this star, nor any III.-type star in the neighbourhood of Schj. 124. The only red star I could find here (1888, Feb. 10) was identified as D. M. – 21°. 2780. R. A. IX.^{h} 18^m 28^s. Decl. – 21°. 28′·2 : mag. 8·7.

350 = Birm. 277. This star and Birm. 278 are certainly identical.

373. Can this star be ψ Virginis, with an error of + 1° in declination?

412. Holden's place is 20^s too little if the star is D. M. – 14°. 4006.

483. Holden, No. 42; R. A. XVIII.^{h} 9^m 59^s. Decl. – 15°. 6′·7; lies near this place. Holden's obs.: 1881, May 29, red yellow star; 7·5 mag. and observed by me, 1886, June 16, 7·5; orange red; and is apparently identical with D. M. – 15°. 4502; 7·0 mag.

— Birm. 495; R. A. XIX.^{h} 21^m 30^s + 19° 34′·8. Ball (private letter to Birm.) in two trials white. My obs., 1886, July 2, makes it white also. Probably No. 551 = Birm. 496 is intended.

563 = Birm. 507. Burton's obs. (1876, July, 19, yellow; 4·5; near it is an orange 8; p. 36^s and 1′ + in Declination) evidently refers to θ Cygni, and not to R Cygni. This is noted also by Mr. Knott (private letter).

579 D. M. + 40°. 3545 agrees with Dunér's place, but he gives + 40°. 3555, a star with same Decl., but f. 1^m 32^s.

613 = Birm. 554. Birm. identifies this star with D. M. + 36°. 4028. It is really D. M. + 36°. 4025 : 1885, July 9; 1887, April 14. The slip is repeated in my obs., A. N., 2788.

IN THE "ADDITIONAL LIST OF RUDDY STARS."

No. 151. Birm. I. 31, II. 5. My impression is that these two stars are really the same. Birmingham's places differ by 13 sec. in R. A., and 0′·7 in Decl. They were observed on the same night; but one is given in the first Addenda, and the other in the second. It seems possible that after the first Addenda had been sent to the printer, the star was found in the observing book, and added to the second Addenda; Mr. Birmingham having forgotten that it had been inserted in the first. He also adds under II. 5, "position very roughly approximated: a bad observation." Mr. Chambers, however, apparently observed two stars here (see his "Working Catalogue of Red Stars," M. N., XLVII., No. 6; Nos. 211, 212); but there is no star in the Südl. D. M., the nearest being D. M. – 5°. 1927, which is 12^s·8 f. B. I. 31, but 18′ 2 s. of it.

ADDITIONAL LIST OF RUDDY STARS.

No.	Bm., &c.	Star's Name.	R. A. (1890) Decl.	Mag.	Observations.
			h m s ° ′		
1	—	− 22°. 7, . .	0 3 18 − 22 47·4	7·2	Sc., r.
2	B. I. 1	. . . .	9 5 + 65 29·8	8·7	Fe., yr. Ch., r^2.
3	—	Mel. I. 16, . .	13 24 − 61 26·5	8½	T., r.
4	B. I. 2	. . . .	29 9 + 67 19·2	6·8	Fe., ro. Ch., r^1.
5	B. I. 3	. . . .	31 21 + 67 2·2	7·3	Fe., yr. Ch., r^2.
6	—	O. A., 325, . .	33 23 − 26 12·3	9	A. C., r.
7	B. 9	α Cassiopeiæ, .	34 16 + 55 56·0	var.	Sc., r^1. Sch., r^2. F., y. Ch., y.
8	L. I. 2	+ 23°. 93, . .	34 43 + 23 59·4	8·0	L., r. Es., o.
9	—	A. G. C., 660, .	38 11 − 44 43·5	7¾	A. C., or.
10	—	− 1°. 104, . .	44 17 − 0 49·4	7·0	A. C., or. V., wy. II.
11	Es. 225	+ 58°. 127, . .	45 49 + 59 7·7	8·8	Es., r. III.
12	B. I. 5	. . . .	46 18 + 69 21·9	7·5	Fe., ry. Ch., o.
13	Es. 143	+ 47°. 255, . .	50 56 + 48 6·4	9·2	Es., r. III.
14	—	L. 256, . . .	50 35 − 28 22·3	6·3	St., r.
15	Es. 186	+ 74°. 46, . .	56 45 + 74 15·3	8·9	Es., r. III.
16	Es. 289	+ 52°. 251, . .	58 26 + 52 37·9	9·0	Es., or. III.
17	B. 16	η Ceti, . . .	I. 3 3 − 10 45·9	3·5	Sch., r^2. F., y. Ch., y. K., yw. II.
18	B. 17	β Andromedæ, .	3 34 + 35 2·4	2·2	Sch., r. F., y. Ch., r. Es., o.
19	L. I. 3	+ 44°. 261, . .	6 10 + 44 43·7	6·5	L., ry ; copper red.
20	L. I. 4	+ 80°. 34, . .	7 36 + 80 58·6	8·0	L., r^2. ; ry.
21	Es. 228	+ 25°. 210, . .	11 22 + 25 41·6	9·0	Es., r. III.
22	Es. 340	+ 60°. 219, . .	15 49 + 60 36·1	9·0	Es., or. Bands, III. ?
23	—	L. 382, . . .	18 4 − 38 16·6	7·4	St., r.
24	Es. 341	+ 60°. 265, . .	26 13 + 60 59·5	8·7	Es., or. III.
25	Es. 291	+ 53°. 352, . .	32 5 + 53 18·1	9·3	Es., r. III.
26	Es. 231	+ 52°. 404, . .	33 54 + 53 0·8	7·5	Es., r. III.
27	—	L. 524, . . .	42 37 − 42 18·2	6·4	T., r.
28	Es. 292	+ 53°. 402, . .	44 33 + 53 19·4	8·7	Es., or. III.
29	—	− 7°. 307, . .	44 44 − 7 15·1	7·4	A. C., r. K., y. II.
30	L. I. 5	+ 75°. 80, . .	47 41 + 75 49·5	7·6	L., r^2. ; r. Es., r. ?
31	Es. 343	+ 69°. 123, . .	47 46 + 69 40·3	8·0	Es., or. III.
32	L. I. 6	+ 75°. 83, . .	49 36 + 75 23·9	7·2	L., r. ; o. Es., o.
33	—	ψ Phœnicis, . .	50 14 − 46 50·5	4·8	A. C., r.
34	Es. 145	+ 44°. 398, . .	51 55 + 44 52·7	8·0	Es., r. III.
35	B. 34	γ Andromedæ, .	57 9 + 41 48·1	2·0	Sch., r^2. Ch., y.
36	Es. 344	+ 65°. 241, . .	II. 6 15 + 65 59·4	8·7	Es., or. III.
37	B. 37	60 Andromedæ,	6 20 + 43 42·8	5·2	Bm., o^1. F., y. Ch., o^1.
38	Es. 232	+ 54°. 497, . .	7 37 + 54 34·5	6·9	Es., r.
39	Es. 293	+ 63°. 312, . .	9 50 + 63 22·5	9·5	Es., r. III.
40	L. I. 7	+ 49°. 628, . .	11 58 + 49 38·0	7·0	L., r.
41	Es. 40	+ 58°. 445, . .	12 26 + 59 9·4	8·8	Es., r.
42	Es. 297	+ 51°. 575, .	19 13 + 51 33·9	9·0	Es., r. III.
43	B. I. 9	15 Trianguli, .	29 6 + 34 12·5	var.	Se., ry. D'A., III. Du., ry. III. Ch., ro.
44	B. 49	η Persei, . . .	42 40 + 55 26·3	3·5	Sch., r. Bm., o. Es., o. F., o. Ch., o.
45	Es. 302	+ 44°. 591, . .	44 28 + 44 36·1	7·8	Es., or. Bands.
46	—	− 20°. 524, . .	44 45 − 20 42·1	8·2	Gore, r^2. ; double.
47	—	L. 952, . . .	48 52 − 74 17·8	7·5	A. Z., r.
48	—	7 Eridani, . .	55 18 − 3 18·9	6·8	Sc., r. Es., o. III.
49	—	. . . .	56 8 − 35 13·6	8½	T., r.
50	B. 52	α Ceti, . . .	56 32 + 3 39·5	2·5	Sch., r^2. Es., o. F., o. Ch., o. Se., III. V., y. III. Du., yr. III.
51	B. 53	ρ Persei, . . .	58 8 + 38 24·8	var.	Sc., yr. Se., r. III. Sch., rr. Bm., o. C., o. D., y. Es., o. F., o. Du., ry. III.
52	B. 56	ω Persei, . . .	III. 4 0 + 40 11·7	5·2	Sch., r. Es., o^1. F., y. Ch., ry.
53	—	L. 1031, . . .	5 18 − 72 25·7	7·8	T., r.
54	—	+ 46°. 715, . .	7 42 + 46 10·2	9·5	Es., r. Deep bands. III.
55	—	L. 1058, . . .	13 52 − 48 9·3	6·2	A. C., r.

No.	Bm., &c.	Star's Name.	R. A. (1890) Decl.					Mag.	Observations.
			h	m	s	°	′		
56	—	+ 64°. 391, . .	III.	15	8	+ 64	11·3	6·0	Do., r.
57	B. 62	σ Persei, . . .		22	49	+ 47	36·9	4·8	Sch., r^3 Do., r. Es., o. F., o. Ch., o′.
58	—	. . . .		23	21	– 51	1·7	8½	T., r.
59	Es. 187	+ 79°. 110, . .		32	24	+ 79	58·2	7·8	Es., r. III.
60	B. 70	π Eridani, . .		40	56	– 12	26·8	4·3	San., r. Sch., r. C., o; y. D., or. Es., o. F., o. Du., ry. III. K., y. III. Ch., ro.
61	—	β Reticuli, . .		42	48	– 65	9·2	3·9	A. C., r.
62	—	– 1°. 539, . .		43	44	– 1	47·3	7·5	A. C., r. V., wy. II.
63	B. I. 11	43 Persei, . .		48	24	+ 50	22·6	—	Sm., *comes* r.
64	—	– 14°. 783, . .		51	20	– 13	55·1	6·8	A. C., or. Du., ry. III. W., or^1.
65	Es. 235	+ 61°. 690, . .	IV.	7	57	+ 62	4·2	7·0	Es., r. III.
66	—	L. 1394, . . .		9	49	+ 40	38·3	6·6	T., r.
67	—	– 21°. 831, . .		13	28	– 20	59·1	6·2	Sc., r.
68	Es. 47	+ 34°. 874, . .		17	7	+ 34	59·3	7·2	Es., or. III. Ch., r.
69	—	L. 1431, . . .		18	30	– 25	8·9	6·1	A. C., r.
70	Es. 310	+ 4°. 696, . .		23	49	+ 4	54·9	7·8	Es., or. III.
71	Es. 311	+ 46°. 893, . .		24	5	+ 46	44·9	9·1	Es., or.; var. ? III.
72	Es. 312	+ 48°. 1106, .		25	21	+ 48	27·6	8·5	Es., or. III.
73	—	– 9°. 930, . .		28	56	– 9	11·8	5·0	U. A., r, Ch., rr.
74	B. 80	58 Persei, . .		29	3	+ 41	2·2	5·0	Sch., r. D., o.; y. Es., o. F., o. Ch., golden.
75	B. 81	α Tauri, . . .		29	36	+ 16	17·3	1·0	F., y. Es., o. V., ry. II. Ch., ro.
76	—	L. 1551, . . .		32	25	– 63	3·0	6·2	A. C., r.
77	Es. 236	+ 16°. 636, . .		33	1	+ 16	31·1	8·0	Es., r. III.
78	—	B. 759, . . .		35	29	– 69	18·4	9¼	T., r.
79	Es. 146	+ 43°. 1047, .		37	32	+ 43	34·7	7·4	Es., r. III.?
80	Es. 237	+ 21. 702, . .		41	14	+ 21	57·8	8·6	Es., r. Bands.
81	B. 87	o^1 Orionis, . .		46	19	+ 14	4·0	5·0	C. des. T., r. Bm., o^1.; y. W., o. C., y; o. D., r.; o. F., o. Es., o. V., yr. III. Se., r. III. Du., ry. III. Ch., ro.
82	Es. 189	+ 58°. 788, . .		47	38	+ 58	55·4	7·0	Es., or. III.
83	Es. 239	+ 16°. 665, . .		47	44	+ 16	31·6	9·3	Es., or. III.
84	B. 89	. . . .		49	51	+ 7	36·0	5·7	C. des T., r. Bm., o^1. D., y.; o^1. Do., y. F., y. Se., III. V., y. II. Ch., y.
85	B. 93	ζ Aurigæ, . .		54	47	+ 40	54·9	3·6	Heis, Weiss, r^3.; y. Sch., yr.; r. Bm., o. C., o. D., y. Gage, y. Es., o. F., o. Du., y. II. Ch., o.
86	B. 95	. . . .		56	11	+ 0	32·8	6·2	Schj., yr. Bm., y. C., y. D., o. Do., y. V., yw. II.
87	—	L. 1686, . . .		57	41	– 26	25·8	5·4	A. C., r.
88	Es. 151	+ 34°. 946, . .		59	10	+ 34	42·4	8·1	Es., r. III.
89	B. 97	ε Leporis, . .	V.	0	48	– 22	31·9	3·1	Sch., r. F., y. H., y. Ch., ro.
90	—	η^3 Pictoris, . .		2	7	– 49	43·6	5·3	A. C., r.
91	—	– 12°. 1080, .		2	44	– 12	44·1	7·0	Sc., r.
92	Es. 152	+ 43°. 1214, .		4	18	+ 43	18·4	8·0	Es., r. III.
93	Es. 48	+ 6°. 865, . .		6	12	+ 6	42·9	7·9	Es., r.; or. III.?
94	—	L. 1754, . . .		7	48	– 37	31·7	6·8	T., r.
95	—	+ 4°. 877, . .		8	54	+ 5	1·7	6·0	Do., r. V., y. II. *a*.
96	—	L. 1809, . . .		16	23	– 34	48·6	6·7	A. C., r.
97	—	h. 3752, . . .		17	15	– 24	52·8	5¾	*Comes* 8, r. Sm.
98	—	27 Orionis, . .		18	53	– 0	59·9	6·0	A. C., rr. V., wy. I. *b*. K., wy. II.
99	Es. 155	32°. 996, . .		21	42	+ 32	23·6	8·8	Es., r. III.
100	—	– 3°. 1136, . .		28	8	– 3	32·8	7·5	Sc., r^3. Es., o^1.
101	—	L. 1890, . . .		29	11	– 35	12·9	6·4	A. C., r.
102	—	L. 1902, . . .		31	12	– 33	9·3	6·0	A. C., r.
103	—	A. G. C., 6519, .		31	20	– 25	48·5	8	T., r.
104	Es. 157	+ 31°. 1049, .		33	33	+ 31	51·4	6·6	Es., or. III.

No.	Bm., &c.	Star's Name.	R. A. (1890) Decl.					Mag.	Observations.
			h	m	s	°	′		
105	—	- 17°. 1199, .	v	34	26	- 17	53·4	6·7	T., r.
106	Es. 55.	+ 50°. 1225, .		38	46	+ 50	2·6	7·1	Es., or. Ch., ro.
107	Es. 57.	+ 32°. 1109, .		44	16	+ 32	5·7	6·6	Es., or. III. Ch., r.
108	—	L. 2026, . . .		46	44	- 37	39·2	7	T., r.
109	Es. 314	+ 45°. 1202, .		48	58	+ 45	28·3	8·5	Es., r. III.
110	B. 127	α Orionis, . .		49	13	+ 7	23·2	var.	F., o^1. Es., o^1. V., yr. III. Du., yr. III. Ch., ro.
111	B. 130	π Aurigæ, . .		51	45	+ 45	55·7	4·8	Hist. Cél., r. Se., gold, y. III. Bm., yo; y^1. W., o. C., y. D., o.; y. F., o. Es., o. Du., ry. III. Ch., ro.
112	—	L. 2108, . . .		57	17	- 33	54·8	5·9	A. C., r.
113	—	A. G. C., 7203, .		59	2	- 46	22·0	8½	A. C., or.
114	Es. 158	+ 47°. 1258, .	VI.	2	1	+ 47	43·0	8·0	Es., r. III.
115	—	+ 22°. 1198, .		2	53	+ 22	12·4	6·5	Do., r^1. Es., or^1. II. III.
116	—	π^2 Columbæ, .		4	28	- 42	8·2	5·8	A. C., r.
117	—	L. 2168, . . .		6	12	- 27	7·8	6·0	A. C., r.
118	B. 139	η Geminorum, .		8	14	+ 22	32·3	var.	Sch., r. V., III. Bm., o^1. Es., o. Do., ry. III. Ch., ry.
119	B. 140	5 Monocerotis, .		9	29	- 6	14·5	4·5	W., o. Bm., o^1. Sc., r. F., y. Es., o. Ch., o^1. K., yw. II.
120	Es. 159	+ 35°. 1577, .		10	41	+ 35	38·7	8·6	Es., r. III.
121	—	η^3 Doradûs, . .		11	1	- 65	33·8	5·5	A. C., r.
122	B. 143	μ Geminorum, .		16	18	+ 22	34·2	3·0	Sch., r. Bm., y. F., y. Es., o^1. V., III. Du., yr. III. Ch., ro.
123	—	- 14°. 1428, .		18	47	- 15	0·8	6·5	T., r.
124	—	+ 11°. 1166, .		19	34	+ 11	17·5	7·9	Do., r^3. V., wy. II.
125	B. I. 29	. . . .		20	9	+ 65	2·8	8·3	Fe., ry.
126	—	L. 2285, . . .		21	8	- 52	7·2	6·4	A. C., r.
127	—	+ 2°. 1253, . .		23	20	+ 2	43·1	6·8	Do., r^1. V., ry. III.
128	—	π^1 Doradûs, . .		23	41	- 69	55·4	6·1	A. C., r.
129	Es. 244	+ 27°. 1136, .		24	7	+ 27	31·3	9·3	Es., r. III.
130	—	- 19°. 1464, .		25	24	- 19	8·4	6·0	T., r.
131	—	- 8°. 1461, . .		26	33	- 8	4·8	5·5	Sc., r. Es., o^1. III.?
132	Es. 163	+ 45°. 1324, .		27	29	+ 45	42·8	8·7	Es., r. III.
133	—	- 14°. 1525, .		34	15	- 14	2·8	5·5	Sc., r^1.
134	—	- 4°. 1610, . .		34	48	- 4	21·1	7·7	Sc., r^2. Es., or^1. III.
135	B. 152	ε Geminorum, .		37	10	+ 25	14·5	3·2	Sch., y. Bm., yo. F., y. Es., o^1. Gage, y.; o. Ch., y.
136	—	L. 2458, . . .		41	10	- 58	22·3	7½	T., r.
137	—	L. 2437, . . .		41	16	- 31	40·0	6·5	A. C., r.
138	B. II. 4	17 Monocerotis, .		41	22	+ 8	9·4	5·3	Bm., ro. V., ry. II. Ch., ry.
139	Es. 192	+ 61°. 915, . .		43	37	+ 61	9·4	8·0	Es., r. III.
140	Es. 166	+ 4°. 1476, . .		46	8	+ 4	53·3	7·9	Es., r. III.
141	—	O. A., 5848, . .		48	35	- 26	49·2	7·0	A. C., r.
142	B. 154	51 Cephei (Hev.),		48	50	+ 87	13·2	5·0	Schwerd, r^3. F., y. Du., yr. III. Ch., o.
143	B. 156	θ Canis, . . .		49	5	- 11	54·1	4·0	Sch., rr. Bm., o. F., o^3. Es., o.; y., var.? Pe., r^3. II. K., y. II. Ch., ro.
144	—	L. 2501, . . .		49	11	- 28	23·3	6·5	T., r.
145	—	L. 2522, . . .		49	27	- 43	50·4	6·7	A. C., r.
146	B. 157	o^1 Canis, . . .		49	34	- 24	2·8	3·9	Sch., rr. F., y. Es., o. H., or. T., r. St., r. A. C., o. Pe., y. II. Ch., o.
147	—	L. 2530, . . .		50	59	- 42	13·6	6·7	T., r. St., r.
148	B. 158	μ Canis, . . .		51	4	- 13	54·1	5·0	Sch., r. Es., y. Pe., r^3. K., yw. II. Ch., rr.
149	—	- 16°. 1671, .		52	9	- 16	57·2	7·5	A. C., or. Es., o. III.?
450	Es. 169	+ 45°. 1379, .		55	30	+ 45	3·6	9·0	Es., r. III.
151	B. I. 31; II. 5	- 5°. 1926 . .		56	33	- 5	33·9	5.0	Bm., ro. Du., ry. III. K., y. III. Ch., o.

No.	Bm., &c.	Star's Name.	R. A. (1890) Decl.					Mag.	Observations.
			h	m	s	°	′		
152	—	L. 2646, . . .	VII.	0	2	− 67	46·0	5·7	A. C., r.
153	—	Ll. 13773, . .		0	6	− 21	51·9	6·7	T., r.
154	—	L. 2615, . . .		2	20	− 24	47·4	6·7	A. C., r.
155	—	A. G. C., 9001, .		2	50	− 52	26·4	10¼	A. C., r.
156	B. I. 32	. . . .		3	6	− 10	27·1	Cl.	Sm., several 9 mag.; reddish.
157	B. 168	H Cameli, . .		7	55	+ 82	37·3	5·5	Redhill Cat., r^2. Do., y. C., y. D., y. Du., ry. III. Ch., ro.
158	—	A. G. C., 9140, .		8	20	− 38	56·8	8¾	A. C., or.
159	Es. 170	+ 48°. 1504, .		9	56	+ 48	42·1	9·0	Es., r. III.
160	—	L^2 Puppis, . .		10	11	− 44	27·7	var.	St., r. A. C., r.
161	—	L. 2697, . . .		12	6	− 27	41·2	5·4	T., r.
162	—	L. 2732, . . .		13	5	− 46	34·8	6·1	A. C., r.
163	—	L. (2730), . .		14	23	− 26	23·1	6·0	A. C., r. Es., o. III.
164	—	F Puppis, . .		14	49	− 39	0·6	5·8	A. C., r.
165	—	+ 20°. 1775, .		15	27	+ 20	38·0	6·0	Do., r. Es., o^1. II.
166	—	L. 2747, . . .		16	27	− 26	45·5	6·7	A. C., r. Es., o.; spect. cont.
167	—	L. 2749, . . .		16	33	− 25	41·1	6·7	A. C., r. Es., or. III.
168	—	A. G. C., 9481, .		19	51	− 31	40·8	8	T., r.
169	—	L. 2891, . . .		21	34	− 78	6·8	8	A. Z., r.
170	—	L. 2853, . . .		22	7	− 71	19·1	7¾	T., r.
171	B. 179	σ Puppis, . .		25	45	− 43	4·8	3·5	Sch., r. Pe., y. II.
172	B. 181	υ Geminorum, .		29	9	+ 27	8·7	4·2	Sch., r. F., o^1. Es., y.; o. Gage, r^1; y. Ch., o.
173	Es. 174	− 5°. 2178, .		30	42	− 5	32·4	8·2	Es., r. III.
174	—	− 21°. 2030, .		31	24	− 21	54·1	6·7	Sc., r. Es., or. III.
175	Es. 353	+ 20°. 1881, .		35	52	+ 20	47·2	9·5	Es., r. III.
176	B. 183	σ Geminorum, .		36	26	+ 29	9·2	5·0	D'A., r. Bm., y. C., y.; o. (an 8, s. p., redder. Es. 27, r^1. Ch., o^1.). F., y. Es., y; o^1. Gage, r^1.; y. Ch., o^1.
177	B. 188	β Geminorum, .		38	36	+ 28	17·5	1·3	Se., o. II. F., y. Ch., y^1.
178	—	O. A., 7305, . .		38	36	− 24	20·4	8¼	T., r. Es., r^2.
179	B. 189	c Puppis, . . .		41	20	− 37	41·8	3·6	h., o. Sch., rr. Pe., o.; spect. cont. Pic., bands.
180	—	+ 5°. 1790, . .		42	13	+ 5	41·1	7·0	Do., or. V., ry. III.
181	—	L. 3011, . . .		43	18	+ 56	27·2	6·4	A. C., r.
182	B. II. 9	ξ Puppis, . .		44	39	− 24	35·0	3·5	Bm., ro. A. C., r. Ch., o.
183	—	A. G. C., 10339,		48	24	− 38	11·3	9½	T., r.
184	—	L. 3075, . . .		51	13	− 44	4·0	7·1	A. C., r.
185	—	L. 3078, . . .		52	53	− 34	5·0	7	T., r.
186	—	L. 3087, . . .		53	22	− 43	12·3	6	A. C., r.
187	—	G. 656, . . .		53	32	− 43	11·3	7¼	T., r.
188	—	L. 3113, . . .		54	27	− 60	13·9	6·3	T., r.
189	—	67 U. A., . .		54	47	− 58	49·8	7·0	A. Z., r.
190	—	A. G. C., 10536,		55	6	− 51	59·7	7¾	T., r.
191	—	A. G. C., 10585,		56	20	− 60	31·0	7¼	T., r.
192	Es. 196	+ 36°. 1735, .		56	29	+ 36	39·4	7·0	Es., or. III.
193	—	A. G. C., 10604,		57	12	− 30	17·2	8	A. C., or.
194	—	L. 3140, . . .		57	45	− 60	17·1	5·5	St., r.
195	—	L. 3188, . . .	VIII.	0	37	− 72	56·2	6·7	T., r.
196	—	L. 3146, . . .		1	30	− 33	15·3	6·6	A. C., r.
197	—	B. 1903, . . .		2	57	− 62	31·4	7¾	A. C., r.
198	—	A. G. C., 10910,		7	35	− 45	31·5	8½	A. C., r.
199	—	L. 3236, . . .		10	23	− 49	51·7	6·0	A. C., r.
200	—	U. A., 282, . .		11	49	− 35	33·9	6·8	A. C., r.
201	—	U. A., 291, . .		15	40	− 22	34·7	6·0	A. C., r. Es., o^1.; spect. cont.
202	—	A. G. C., 11348,		22	46	− 36	19·1	8	A. C., r.
203	—	B. 2062, . . .		26	40	− 40	7·8	7¾	T., r. St., r.

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			h	m	s	°	′		
204	—	L. 3479, . . .	VIII.	37	16	− 50	37·4	7½	T., r.
205	—	L. 3568, . . .		42	52	− 67	48·7	6·8	T., r.
206	B. II. 39	σ^1 Ursæ, . . .		58	44	+ 67	18·9	5·2	Fe., r^2. Ch., o. F., o.
207	B. 219	π^2 Cancri, . .	IX.	9	10	+ 15	24·0	5·8	Sch., r. F., o^1. Es., o^1. Ch., o^1. V., wy. II.
208	B. 220	40 Lyncis, . .		14	22	+ 34	51·4	3·1	Sch., r. F., o. Es., o. Ch., ro. Du., ry. II.
209	—	L. 3832, . . .		21	20	− 39	50·3	7½	St., r.
210	—	− 20°. 2915, .		24	10	− 20	16·1	5·7	H., oy. Ch., rr. Bellamy red.
211	B. I. 40	. . . .		25	11	+ 67	16·9	7·2	Fe., r. Bm., not r.
212	—	L. 3863, . . .		25	17	− 23	47·5	7¼	T., r.
213	B. 224	λ Leonis, . .		25	27	+ 23	27·3	4·5	Sch., r. F., o^1. Es., o.; y. Gage, y. Ch., ro.
214	B. I. 41	6 Leonis, . . .		26	4	+ 10	12·1	6·0	Sm., r^1. W., o. Main, y^1. Sadler, w.; rw.; o. V., y. II.
215	B. 226	ι Hydræ, . . .		34	14	− 0	38·6	4·0	Sch., r. F., o. Es., o^1. Ch., o. V., y. II.
216	—	L. 3967, . . .		35	30	− 30	25·4	7¼	St., r.
217	—	L. (4014), . .		41	55	− 45	24·6	7	A. C., r.
218	B. 231	π Leonis, . . .		54	24	+ 8	34·3	5·0	Sch., r. F., o^1. Es., o. Gage, ro. Ch., ro. V., y. III. Du., ry. III.
219	—	A. G. C., 13625,		54	39	− 46	57·8	7¾	T., r.
220	L. I. 12	+ 35°. 2102, .		59	21	+ 35	31·4	7·0	L., r.
221	—	L. 4151, . . .	X.	0	6	− 59	40·0	8	T., r.
222	—	− 16°. 2974, .		1	53	− 16	36·2	5·3	Sc., r^2. Es., o^1. II.? U. A., r.
223	B. 233	31 Leonis, . .		2	4	+ 10	32·3	5·0	Sch., or. F., o^1. Es., o. Gage, r. Ch., o. V., y. II.
224	—	− 6°. 3078, . .		2	17	− 7	5·6	6·8	T., r. Es., or^1. III.
225	Es. 30	+ 42°. 2108, . .		10	47	+ 42	21·1	6·5	Es., r. var.? Ch., o.
226	—	Ll. 20079, . .		15	2	− 22	33·0	7¾	T., r.
227	—	L. 4263, . . .		15	29	− 54	28·6	5·4	T., r. Tupman, red.
228	B. 238	μ Ursæ, . . .		15	47	+ 42	3·1	3·1	Sch., r. F., o. Es., o.; y. Du., ry. III. Ch., o.
229	—	B. 3010, . . .		21	34	− 54	25·8	7·4	T., r.
230	Es. 359	+ 45°. 1924, . .		22	1	+ 45	48·4	6·8	Es., or. III.
231	—	A. G. C., 14275,		22	25	− 68	18·0	8¼	T., r.
232	—	L. 4305, . . .		23	32	− 48	50·6	6·6	St., r.
233	L. I. 13	+ 37°. 2089, .		24	29	+ 37	2·5	9·1	L., r. Es., y^1.
234	—	L. 4330, . . .		25	13	− 63	36·6	6·1	St., r.
235	—	B. 3068, . . .		27	13	− 70	19·5	7¾	A. C., r.
236	Es. 360	+ 42°. 2131, .		28	40	+ 42	28·6	7·1	Es., or. III.
237	L. I. 14	+ 37°. 2099, .		29	37	+ 37	30·2	8·1	L., r. Es., w.
238	—	. . . .		30	22	− 57	34·7	9¼	T., r., in cluster.
239	—	A. G. C., 14446,		30	25	− 62	8·6	7½	A. C., 7½, r.
240	—	L. 4375, . . .		31	38	− 57	39·3	7½	T., r., in cluster.
241	—	t^3 Carinæ, . .		34	34	− 58	36·6	5½	T., r. St., r. Tupman, orr.
242	—	. . . .		39	13	− 59	45·3	8	A. C., r., in Cl.
243	—	. . . .		40	31	− 58	50·4	8¾	A. C., r., in Cl.
244	—	. . . .		40	43	− 59	21·4	8	A. C., r., in Cl.
245	—	η Carinæ, . .		40	48	− 59	6·4	var.	Orange; several observers.
246	—	L. 4453, . . .		40	55	− 46	52·9	7¼	St., r. A. C., o.
247	—	B. 3204, . . .		41	33	− 58	54·6	7½	A. C., r., in Cl.
248	—	O. A., 10887, .		42	24	− 31	1·3	7¾	A. C., r.
249	—	L. 4492, . . .		45	31	− 48	31·8	7¾	T., r.
250	—	B. 3244, . . .		46	6	− 59	24·0	7¾	St., r.
251	—	L. 4500, . . .		47	24	− 54	33·3	7½	St., r.
252	—	+ 23°. 2279, .		50	22	+ 22	56·7	6·2	Do., r^1. Es., o.; spect. cont.
253	B. 251	60 Leonis, . .		56	25	+ 20	46·3	4·3	Sch., r. Do., yellowish? F., green. Es., white. (Suspect Sch. means 61 Leonis, which is o.) Gemmill, y^1. Ch., y^1.

No.	Bm., &c.	Star's Name.	B. A. (1890) Decl.					Mag.	Observations.
			h	m	s	°	′		
254	—	L. 4567, . . .	X. 57	9	− 40	31·3		6·9	A. C., r.
255	—	L. 4579, . . .	58	35	− 60	19·1		7·2	St., r. A. C., y.
256	—	A. G. C., 15352,	XI. 7	41	− 59	46·8		8	A. C., r.
257	Es., 198	− 11°. 3063, .	10	8	− 11	59·5		6·5	Es., or. III.
258	—	L. 4670, . . .	10	17	− 40	27·4		7¼	A. C., r.
259	B. 259	ν Ursæ, . . .	12	32	+ 33	41·6		3·4	C. des T., r. Se., gold y. II. Do., r.; o. C., y. D., o. F., o. Es., o. Ch. y.
260	—	B. 3574, . . .	19	55	− 61	2·8		8½	A. C., r.
261	—	B. 3586, . . .	22	3	− 60	45·8		7¼	St., r.
262	—	L. 4749, . . .	22	11	− 25	15·4		6·9	T., r.
263	B. 261	87 Leonis, . .	24	42	− 2	23·8		5·0	Sch., r. F., o^1. Es., o^1. Ch., o. Es., spect. cont.
264	B. 262	λ Draconis, . .	24	52	+ 69	56·3		3·3	Sch., r. F., o. Es., o. Ch., o. Do., yr. III.
265	—	L. 4776, . . .	27	28	− 30	28·8		5·8	T., r.
266	B. 263	90 Leonis, . .	28	59	+ 17	24·2		—	Sm., *comes*, r^1.
267	—	L. (4820), . .	32	26	− 60	17·6		7·3	T., r.
268	—	A. G. C., 15946,	34	33	− 71	57·0		8½	A. C., r.
269	—	L. 4846, . . .	35	24	− 53	21·5		6·7	St., r.
270	—	L. 4847, . . .	35	39	− 40	16·5		7·6	T., r.
271	—	L. 4857, . . .	36	14	− 31	53·3		5¾	A. C., r.
272	B. 266	χ Ursæ, . . .	40	15	+ 48	23·4		4·0	Sch., r. F., o. Es., o.
273	B. 267	β Leonis, . . .	43	28	+ 15	11·2		—	Sm., *comes* 8, r. W., violet or ruddy. Es., r^1; w.
274	—	A. G. C., 16211,	47	5	− 48	4·2		9	A. Z., r.
275	—	L. 4928, . . .	48	37	− 30	17·7		7½	T., r.
276	—	L. 4934, . . .	48	57	− 56	21·4		7	A. C., r.
277	—	L. 4980, . . .	56	8	− 68	35·1		7·4	T., r.
278	—	Cl., 27, . . .	56	52	− 85	1·1		6·6	T., r.
279	L. I. 16	+ 69°. 639, . .	58	6	+ 69	32·9		8·0	L., r.
280	L. I. 17	+ 69°. 641, . .	XII. 0	4	+ 69	21·7		8·2	L., r.
281	L. I. 18	+ 69°. 642, . .	0	4	+ 69	24·6		7·5	L., r.
282	—	L. 5032, . . .	2	41	− 60	14·1		6·8	St., r.
283	L. I. 19	+ 78°. 406, . .	4	42	+ 78	0·0		7·0	L., r.
284	L. I. 20	+ 29°. 2268, .	7	30	+ 29	14·6		7·9	L., ry.; r.
285	—	L. 5063, . . .	7	31	− 33	30·8		6·9	Pe., r^2. III.
286	—	D Centauri, . .	8	18	− 45	6·7		6½	Pe., r. Spect. cont.
287	—	F Centauri, . .	13	8	− 54	31·9		5·8	A. C., r.
288	—	L. 5114, . . .	15	55	− 49	20·3		6·9	A. C., r.
289	—	L. 5124, . . .	17	52	− 76	36·3		7½	T., r.
290	—	L. 5157, . . .	21	25	− 58	23·0		6·4	St., r. A. C., r. Pe., r^2. III.
291	—	L. 5175, . . .	23	50	− 55	55·0		5·9	St., r. A. C., r.
292	—	L. (5173), . .	24	4	− 41	7·6		6·6	A. C., r.
293	B. I. 44	4 Draconis, . .	25	19	+ 68	48·4		4·7	Fe., yr. Bm., y^1. Es., ro. Ch., ro. Du., ry. III. F., o.
294	—	B. 4090, . . .	26	4	− 55	31·3		7·0	T., r.
295	L. I. 21	+ 23°. 2467, .	26	16	+ 23	34·0		7·4	L., r^2.
296	—	L. 5192, . . .	26	22	− 26	57·5		7½	A. C., r.
297	L. I. 22	+ 25°. 2522, .	28	3	+ 25	3·3		7·3	L., r^2.; ry. Es., r. III.
298	—	L. 5203, . . .	28	28	− 67	9·0		7·1	A. Z., r.
299	—	A. G. C., 17211,	33	4	− 63	12·2		9	A. C., r.
300	—	A. G. C., 17215,	33	8	− 48	27·7		8½	A. C., r.
301	L. I. 23	+ 23°. 2479, .	33	34	+ 23	14·9		7·0	L., r^2.; o; ry.
302	—	− 11°. 3353, .	38	4	− 11	24·6		6·5	Sc., r.
303	—	L. 5302, . . .	46	54	− 30	36·2		6·8	A. C., r.
304	—	A. G. C., 17539,	48	8	− 68	18·6		7½	A. C., r.
305	Es. 370	+ 47°. 2003, .	49	55	+ 47	47·4		5·8	Es., or. III.

No.	Bm., &c.	Star's Name.	R. A. (1890) Decl.					Mag.	Observations
			h	m	s	°	′		
306	B. 297	δ Virginis, . .	XII.	50	3	+ 3	59·8	3·0	Sch., r. Sm., y., *comes* r^{2}. F., y. Es., y. Gage, o. Ch., y. V., y. III. Du., ry. III.
307	Es. 371	+ 35°. 2387, .		53	46	+ 35	8·9	8·0	Es., r^{1}. III.
308	—	A. G. C., 17818,	XIII.	0	5	− 50	27·6	8	A. Z., r.
309	L. II. 1	+ 28° 2187, . .		2	39	+ 28	8·0	6·8	L., y. ; r^{2}.
310	—	A. G. C., 18000,		8	2	− 34	6·1	9	T., r.
311	—	L. 5460, . . .		10	9	− 44	7·4	7·2	St., r. A. C., r.
312	B. 302	σ Virginis, . .		12	3	+ 6	3·0	5·2	Sch., r. Es., o^{1}. V., y. III. Du., yr. III. Ch., ry.
313	B. 303	γ Hydræ, . .		12	56	− 22	35·4	3	C. des Temps ; r. Bm., y^{1}. F., o^{1}. Es., o^{1}. D., or. ; r^{2}. Ch., o^{1}. Pe., y. ; spect. cont. Se., y. II. Sch., y.
314	Es. 200	. . . .		17	19	− 24	4·8	8	Es., r. III.
315	—	A. G. C., 18289,		20	31	− 42	30·4	9	A. C., r.
316	B. 306	68 Virginis, . .		20	55	− 12	8·1	5·2	C. des Temps; r. Bm., o^{1}. F., o. D., o. Du., ry. III. K., y. II. Ch., r^{1}.
317	B. 309	74 Virginis, . .		26	15	− 5	41·3	5·5	Sch., r. Es., o. F., o. H., y. Ch., o. Du., yr. III. K., yw. III.
318	Es. 376	+ 37°. 2417, . .		26	22	+ 37	2·9	7·0	Es., or. III.
319	—	L. 5622, . . .		33	12	− 49	23·5	6·8	A. Z., r.
320	—	L. 5624, . . .		33	14	− 39	11·3	6·7	St., r.
321	—	L. 5660, . . .		39	31	− 62	2·3	6·8	A. C., r.
322	—	L. 5674, . . .		40	45	− 49	46·2	6·0	A. C., r.
323	B. 314	υ Bootis, . . .		44	11	+ 16	20·6	4·2	Argel., r. Sch., ry. Bm., y. Ball, y^{1}. D., or. F., oy. Es., o., y., y^{1}. V., y. III. Du., ry. III. Ch., or.
324	B. 315	10 Draconis, . .		48	13	+ 65	16·0	4·8	Sch., r. W., y. Do., r^{1}. F., o. Es., yr., Du., ry. III.
325	B. 316	. . . .		48	29	+ 40	52·7	6·7	D'A., fusca. Se., y. D'A., 1873, hellbraun. Bm., y^{1}. D., o^{1}. Es., r^{1}. Du., yr. III. ? Ch., o.
326	—	+ 53°. 1667, .		49	12	+ 52	51·9	6·3	Do., ry.
327	Es. 201	+ 19°. 2728, .		50	3	+ 19	13·9	7·9	Es., r. III.
328	—	A. G. C., 18947,		50	54	− 55	48·9	8	A. C., r.
329	—	θ Apodis, . .		54	38	− 76	15·9	var.	T., r. H., or.
330	—	L. 5795, . . .		58	48	− 61	50·8	7½	T., r.
331	B. 320	13 Bootis, . .	XIV.	4	10	+ 49	58·6	5·5	Bm., o. ; *comes* 280°. F., o^{1}. Es., o^{1}. D., o. Ch., r^{2}. Du., ry. III.
332	B. 321	− 15°. 3817, .		4	50	− 15	46·9	5·0	Se., rossa viva. D'A., rr. H., y. ; ry. Es., o^{1}. ; or^{2}. III. Du., ry. III. Ch., r.
333	—	L. 5840, . . .		5	52	− 53	8·9	6·1	A. C., r.
334	—	L. 5848, . . .		6	7	− 41	7·5	7·2	A. C., r.
335	—	A. G. C., 19254,		6	42	− 53	25·0	7½	A. C., r.
336	B. 322	κ Virginis, . .		7	2	− 9	45·7	4·0	Sch., r. Es., y. K., wy. I. Ch., r^{2}.
337	B. 324	4 Ursæ Minoris,		9	17	+ 78	3·9	5·0	Schwerd, r^{2}. Bm., o^{1}. Do., r^{1}. Ch., o.
338	—	A. G. C., 19416,		15	4	− 49	20·7	8½	A. Z., r.
339	—	L. 5903, . . .		16	0	− 50	16·2	6·7	A. C., r.
340	—	L. 5835, . . .		16	46	− 83	39·4	7½	T., r.
341	Es. 302	+ 30°. 2513, .		17	25	+ 29	52·8	6·5	Es., or. III.
342	—	L. 5920, . . .		18	58	− 58	44·4	7·5	A. C., r.
343	L. I. 26	+ 22°. 2697, .		19	45	+ 21	51·8	7·1	L., r^{2}. ; r. Es., r^{1}. III.
344	—	A. G. C., 19548,		20	28	− 59	10·7	8½	A. Z., r.
345	—	A. G. C., 19581,		22	2	− 49	37·0	8	A. Z., r.
346	—	L. 5955, . . .		23	34	− 39	59·1	7½	A. C., r.
347	—	L. 5944, . . .		24	50	− 73	12·5	7	T., r.

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348	—	L. 5969, . . .	xiv.	25	57	− 52	11·5	6·5	A. C., r.
349	—	L. 5978, . . .		26	41	− 45	58·7	7·5	T., r.
350	B. 330	ρ Bootis, . . .		27	5	+ 30	51·2	4·0	C. des Temps ; r. D'A., hellbraun. Bm., y^1. D., y. F., o. Es., o^1. ; o. Ch., o. Du., ry. ɪɪ.
351	B. 332	5 Ursæ Minoris,		27	46	+ 76	11·1	5·0	Sch., r. Do., r^1. F., o. Es., o. Ch., y.
352	B. 335	α^1 Centauri, . .		32	12	− 60	23·0	1·0	Engelmann, r. Pe., r^3. Russel, y. Tupman, y.
353	Es. 378	+ 38°. 2578, .		35	36	+ 38	34·0	7·0	Es., or. ɪɪɪ.
354	—	A. G. C., 19913,		36	28	− 61	3·2	7¼	A. C., r.
355	B. 337	34 Bootis, . .		38	35	+ 27	59·8	5·8	Sch., r. Bm., yo. D., o. Do., r. F., o. Es., o. Ch., ro. Se., yr. ɪɪɪ. D'A., ry. ɪɪɪ Du., ry. ɪɪɪ.
356	—	L. 6090, . . .		40	49	− 39	27·9	7·0	A. Z., r.
357	—	L. (6078), . .		40	54	− 58	56·8	6·9	T., r.
358	—	L. 6096, . . .		42	47	− 54	33·1	7	A. C., r.
359	B. 340	σ Libræ, . . .		43	50	− 27	30·1	4·8	Sch., r. Pe., o. Ch., r.
360	B. 341	β Ursæ Minoris,		51	2	+ 74	36·3	2·1	Sch., rr. Do., r. Es., o. Ch., y.
361	B. 343	20 Libræ, . .		57	38	− 24	50·9	3·5	Sch., r. Pe., o. ɪɪɪ., ɪɪ. Pickering ; bands. A. C., o. F., o. Ch., or.
362	B. 344	ν Libræ, . . .	xv.	0	29	− 15	49·8	5·3	Sch., rr. H., y. F., o^1. Ch., ro.
363	—	B. 5214, . . .		5	4	− 51	33·3	7½	A. C., or.
364	Es. 205	− 1°. 3041, . .		9	16	− 1	59·5	8·0	Es., r. ɪɪɪ.
365	B. 346	δ Lupi, . . .		11	8	− 29	44·6	4·7	Greenwich Cat., rr. Se., y. Pe., r^2. Ch., r.
366	B. 351	11 Ursæ Minoris,		17	12	+ 72	13·4	5·5	Sch., y. F., o., Es., o. Ch., r^2.
367	—	Ll. 28090, . .		19	43	− 20	59·6	8	A. C., or.
368	—	L. 6380, · . .		21	45	− 46	21·0	5·9	T., r.
369	B. 352	ι Draconis, . .		22	29	+ 59	21·1	3·0	Sch., y. Bm., ro. Ch., y.
370	L. ɪɪ. 4	+ 37°. 2643, .		22	40	+ 37	40·3	8·3	L., r. Es., faintly red.
371	L. ɪɪ. 5	+ 37°. 2651, .		26	19	+ 37	10·2	6·5	L., r^1 ; r. Es., o.; spect. cont.
372	—	R Normæ, . .		28	3	− 49	8·3	var.	T., r.
373	B. 353	γ Libræ, . . .		29	22	− 14	25·3	4·0	Sch., y. F., o^1. K., yw. ɪɪ.
374	Es. 67	+ 27°. 2509, .		29	27	+ 26	53·7	8·2	Es., r^1. ; r. ɪɪɪ.
375	B. 355	39 Libræ, . .		30	21	− 27	46·2	3·9	Sch., r. Ch., r.
376	—	ω Lupi, . . .		30	39	− 42	12·3	4·7	T., r.
377	Es. 68	+ 24°. 2901, .		33	33	+ 24	52·9	7·4	W., or. Es., or^1. ɪɪɪ. Ch., r.
378	B. 357	θ Ursæ Minoris,		34	41	+ 77	42·9	5·0	Sch., r. Do., r^1. F., o. Es., o. Ch., r^2.
379	B. ɪɪ. 12	ζ^1 Coronæ, . .		35	14	+ 36	59·6	4·3	Bm., ro. ; with blue *comes.*
380	Es. 206	+ 39°. 2901, .		37	23	+ 38	55·1	7·0	Es., r. ɪɪɪ.
381	—	B. 5466, . . .		40	11	− 49	24·0	7¾	T., r.
382	B. 358	κ Serpentis, . .		43	47	+ 18	30·0	4·0	Sch., r. Bm., o. F., o. Es., o. V., ry. ɪɪɪ. Du., ry. ɪɪɪ. Ch., o.
383	B. 363	ρ Serpentis, . .		46	25	+ 21	18·6	5·0	Sch., rr. F., o. Es., o. Ch., o^1.
384	—	A Scorpii, . .		47	0	− 24	59·9	5½	T., r.
385	B. 365	θ Libræ, . . .		47	34	− 16	24·4	4·8	Sch., y. Ch., o^1.
386	—	Melb. ɪ. 801, .		50	55	− 66	31·9	7½	A. C., r.
387	—	L. 6631, . . .		52	46	− 26	42·1	7½	A. Z., r.
388	B. ɪɪ. 14	ϵ Coronæ, . .		53	2	+ 27	11·8	4·0	Bm., ro. F., o^1. Es., o.
389	—	L. 6666, . . .		57	42	− 28	37·6	8	A. C., r.
390	—	L. (6661), . .		59	43	− 52	46·9	7¼	St., r. A. C., o.
391	—	L. 6702, . . .	xvi.	1	25	− 26	1·9	6·0	H., ry. Ch., r.
392	—	. . . .		3	4	− 26	9·0	—	H., 7·5 ; ry. Ch., r.
393	B. 370	+ 8°. 3141, . .		3	10	+ 8	50·2	6·4	D'A., goldgelb. V., ry. ɪɪɪ. Du., ry. ɪɪɪ. Es., o. Ch., r.
394	B. 371	+ 9°. 3153, . .		3	19	+ 8	55·2	7·5	D'A., goldgelb. V., ry. ɪɪɪ. Du., ry. ɪɪɪ. Es., or^1.
395	—	A. G. C., 21996,		7	56	− 32	10·0	8½	A. C., or.

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396	B. 373	δ Ophiuchi, . .	XVI.	8	35	− 3	24·6	3·0	Sch., rr. F., o. Es., o. Du., yr. III. Ch., ro.
397	L. II. 6	+ 36°. 2714, .		11	51	+ 36	49·8	7·0	L., r^2; ry.
398	L. II. 7	+ 36°. 2715, .		11	54	+ 36	8·8	7·9	L., r^2. r.
399	L. II. 8	+ 36°. 2717, .		12	19	+ 36	21·6	8·6	L., r.
400	B. 375	ε Ophiuchi, . .		12	30	− 4	25·5	3·3	Sch., y. Ch., y. K., w. I.
401	—	A. G. C., 22102,		12	30	− 39	15·1	8½	A. C., r.
402	B. 376	ν^1 Coronæ, . .		18	13	+ 34	4·5	5·2	D'A., o. Ch., o. W., y. Du., ry. III.
403	B. 377	ν^2 Coronæ, . .		18	21	+ 33	57·3	5·3	D'A., o. Ch., o. W., y. F., y. Du., ry. III. (Sm., *comes* r.)
404	—	L. 6827, . . .		20	35	− 57	30·6	6·6	A. C., r.
405	—	B. 5732, . . .		21	14	− 52	9·5	8	T., r.
406	—	− 7°. 4292, . .		21	48	− 7	20·7	6·1	Sc., r. K., y. III. II*a*.
407	B. 381	α Scorpii, . .		22	40	− 26	11·2	1·4	Sch., rr. F., o. Es., o. Sm., rr. Ch., rr. Du., yr. III. Pe., III. II.
408	B. 383	β Herculis, . .		25	30	+ 21	43·8	2·5	Sch, y. Ch., golden.
409	—	L. 6875, . . .		26	1	− 31	19·0	7½	A. C., r.
410	—	L. 6876, . . .		27	13	− 45	0·6	7	A. C., r.
411	—	B. 5786, . . .		32	33	− 44	21·3	7½	A. C., r.
412	—	L. 6895, . . .		32	46	− 62	20·3	6·9	St., r.
413	—	B. 5810, . . .		37	38	− 66	52·9	7½	A. C., or.
414	—	− 18°. 4320, . .		39	4	− 18	55·9	6·7	Sc., r.
415	B. 387	43 Herculis, . .		40	33	+ 8	47·2	5·6	South & Hersch.; dpl.; 5, 9; r. bluish. F., o. V., ry. II*a*. Du., yr. III.
416	B. 390	+ 36°. 2785, . .		45	21	+ 36	38·5	9·0	Burton, ro.
417	—	L. 7049, . . .		48	47	− 33	19·8	7·0	A. C., r.
418	B. 395	κ Ophiuchi, . .		52	28	+ 9	32·8	3·0	Sch., y. Es., o^1. V., wy. II. Ch., golden.
419	—	L. 7082, . . .		53	14	− 24	55·5	6·3	A. C., or.
420	B. 400	61 Herculis, .		59	36	+ 35	33·8	6·5	D'A., yr. Du., ry. III. Ch., o^1.
421	L. I. 30	+ 31°. 2956, .	XVII.	0	25	+ 31	33·9	7·6	L., ry.; r^2.; rr.
422	L. I. 31	+ 31°. 2962, .		1	25	+ 31	15·5	8·5	L., r.; rr.
423	L. I. 32	+ 31°. 2964, .		2	43	+ 31	10·3	8·2	L., r.; ry. rr.
424	L. II. 9	+ 31°. 2965, .		2	56	+ 31	13·2	8·5	L., r.
425	—	A. G. C., 23248,		4	8	− 32	11·5	7¼	A. C., r.
426	—	L. 7171, . . .		6	50	− 39	38·1	7·0	T., r. St., r.
427	—	L. 7170, . . .		9	28	− 59	34·4	6·5	A. C., r.
428	B. 402	α Herculis, . .		9	38	+ 14	30·9	var.	Sch., r. Sm., o. Σ., egregie flava. W., o.; oy. F., o. Es., o. Se., III. V., yr. III. Du., yr. III. Ch., o.
429	B. 403	δ Herculis, . .		10	31	+ 24	58·3	5·0	Sm., *comes* r. Dembowsky; bleu clair.
430	—	− 15°. 4502, . .		10	59	− 15	5·3	7·0	H., ry. Ch. rr.
431	B. 404	π Herculis, . .		11	13	+ 36	56·0	3·0	Sch., rr. F., o. Es., o. Ch., o.
432	—	L. 7235, . . .		14	29	− 41	0·6	7¼	A. C., r.
433	—	L. 7250, . . .		14	57	− 24	47·7	6·8	A. C., r.
434	Es. 73	+ 17°. 3225, . .		15	53	+ 17	9·4	7·8	Es., r^1. Ch., r.
435	—	L. 7324, . . .		24	32	− 33	37·0	6·6	T., r.
436	L. I. 33	+ 52°. 2058, . .		24	33	+ 51	58·1	8·1	L., r^2.; r.
437	Es. 382	+ 71°. 841, . .		25	10	+ 71	58·0	6·8	Es., or. III.
438	B. 411	λ Herculis, . .		25	17	+ 26	11·6	5·0	Sch., y. F., o^1. Es., o. Ch., o^1.
439	—	L. 7323, . . .		25	54	− 48	26·9	7·0	A. C., r.
440	—	L. 7328, . . .		28	10	− 59	21·6	7·5	T., r.
441	—	A. G. C., 23824,		28	23	− 38	23·9	8	T., r.
442	—	L. 7375, . . .		33	28	− 50	27·0	6·9	A. C., r.
443	—	A. G. C., 23955,		34	37	− 57	57·3	7·4	T., r.
444	—	L. 7397, . . .		35	23	− 36	53·3	6·2	T., r.
445	—	L. 7402, . . .		35	54	− 32	59·8	6·7	A. C., r.
446	—	L. 7409, . . .		36	24	− 32	33·1	7·2	A. C., r.

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447	B. 417	β Ophiuchi, . .	XVII.	38	1	+ 4	36·7	3·0	Sch., y. Es., y^1. V., y. II*a*. Ch.,o^1.
448	—	L. 7327, . . .		43	26	− 81	28·2	7·0	T., r.
449	—	L. 7458, . . .		43	48	− 40	44·3	6·5	T., r.
450	—	L. 7470, . . .		45	32	− 34	5·2	7	A. C., or.
451	Es. 383	+ 45°. 2602, .		45	40	+ 45	44·5	8·2	Es., or. III.
452	—	Ll., 32766, . .		50	17	− 23	55·6	7·5	A. C., r.
453	L. II. 10	+ 22°. 3237, . .		51	14	+ 22	28·9	5·0	L., r^2. ; ry.
454	B. 421	ξ Draconis, . .		51	37	+ 56	53·4	3·5	Sch., y. Ch., o^1.
455	B. 423	γ Draconis, . .		54	3	+ 51	30·1	2·2	Sch., rr. Bm., yo. Ch., o.
456	—	L. 7517, . . .		54	42	− 59	10·6	7·0	T., r.
457	L. II. 11	+ 22°.3256, . .		56	50	+ 22	46·2	7·5	L., r.
458	L. II. 12	+ 22°. 3259, .		57	22	+ 22	27·4	7·2	L., r.
459	—	L. 7549, . . .		58	37	− 41	45·9	8	T., r.
460	—	L. 7561, . . .	XVIII.	3	42	− 63	42·7	6·9	A. C., or.
461	B. 429	μ Sagittarii, . .		7	11	− 21	5·2	4·0	Sm., y^1. ; *comites* r^3. W., *comites* r^3. and blue.
462	B. 430	104 Herculis, .		7	47	+ 31	22·7	5·0	Se., yr. III. F., o. Es., o. Du., ry. III. Ch., o.
463	B. 432	η Sagittarii, . .		10	11	− 36	47·6	3·3	Sch., y.
464	—	L. 7659, . . .		11	10	− 27	4·9	5·1	A. C., or.
465	—	. . . . . .		12	31	− 17	34·3	7¾	T., r.
466	B. 433	+ 23°. 3299, .		13	32	+ 23	14·3	7·0	Bm., o. Es., r^1. Ch., o.
467	B. 434	δ Sagittarii, . .		13	57	− 29	52·5	2·8	Sch., r. Ch., or.
468	B. 440	109 Herculis, .		19	0	+ 21	43·3	4·5	Sch., y. F., o^1. Es., o^1. Ch., y.
469	B. 441	λ Sagittarii, . .		21	11	− 25	28·9	2·7	Sch., y. Ch., ro.
470	Es. 211	+ 25°. 3545, .		25	48	+ 25	6·7	9·0	Es., r. III.
471	—	− 14°. 5099, .		26	26	− 14	56·7	5·8	A. C., r. Es., or. III.
472	—	24 Sagittarii, .		27	10	− 24	6·8	5·9	A. C., or. F., o^1.
473	—	L. 7765, . . .		27	37	− 39	46·6	6·5	A. C., or.
474	—	112 Sagittarii, .		28	54	− 19	21·2	7·0	A. C., r.
475	B. 449	1 Aquilæ, . .		29	13	− 8	19·1	4·2	Sch., r. Es., o. Ch., o.
476	Es. 82	+ 38°. 3219, .		30	26	+ 38	21·2	7·3	Es., or. Ch., r.
477	—	− 7°. 4648, . .		34	3	− 7	53·3	6·1	Sc., r. K., wy. II.
478	—	L. 7797, . . .		35	10	− 61	12·1	6·5	A. C., r.
479	—	− 1°. 3544, . .		36	49	− 1	24·2	8·2	Es., or. III.
480	—	L. 7862, . . .		43	1	− 52	31·2	7½	A. C., r.
481	—	L. 7872, . . .		44	17	− 46	43·4	5·9	A. C., or.
482	—	− 8°. 4726, . .		44	22	− 8	2·0	7·1	A. C., or. Sc., r.
483	Es. 212	+ 46°. 2563, .		48	7	+ 46	37·0	8·3	Es., or. III.
484	B. 468	ν^2 Sagittarii, .		48	28	− 22	48·5	6·2	Sch., r. F., o^1. Ch., o^1.
485	B. 470	δ^2 Lyræ, . . .		50	39	+ 36	45·5	4·5	Sch., rr. F., o. Es., o. Ch., o. Du., yr. III.
486	B. 471	ξ^2 Sagittarii, .		51	10	− 21	15·0	4·0	Sch., r. Ch., o.
487	B. 474	R Lyræ, . . .		51	59	+ 43	48·1	var.	Sc., r. D'A., yr. Sch., r. Bm., o. Ball, y. F., y. Es., y.; o.
488	Es. 214	+ 47°. 2727, .		54	59	+ 47	16·3	8·2	Es., or. III.
489	B. 478	12 Aquilæ, . .		55	48	− 5	53·6	4·7	Sch., y. Bm., r. ; no col. Es., o^1. Ch., o. K., wy. I.
490	B. 479	λ Lyræ, . . .		55	51	+ 31	59·4	5·8	Sch., r. Bm., o., var. ? Es., o. Ch., o.
491	B. 481	o Sagittarii, . .		58	5	− 21	54·1	4·2	Sch., y. Ch., y.
492	Es. 250	+ 1°. 3880, . .		59	32	+ 1	26·8	8·8	Es., or. III.
493	B. 485	τ Sagittarii, . .	XIX.	0	5	− 27	49·6	3·6	Sch., y. Ch., ro.
494	—	L. 8006, . . .		3	47	− 51	59·0	7·1	A. C., r.
495	Es. 326	+ 30°. 3497, .		12	30	+ 30	56·5	8·0	Es., or.
496	B. 491	δ Draconis, . .		12	32	+ 67	28·1	3·4	Sch., y. Sm., *comes* r^1. Ch., y.
497	L. II. 13	+ 73°. 854, . .		14	48	+ 73	41·5	8·2	L., ry. ; rr. ; r. Es., o.
498	—	− 4°. 4781, . .		14	59	− 4	42·2	7·0	Sc., r^3.

No.	Bm., &c.	Star's Name.	R. A. (1890) Decl.					Mag.	Observations.
			h	m	s	°	'		
499	—	A. G. C., 26511,	xix.	15	51	− 57	11·3	10½	T., r.
500	—	+ 9°. 4075,		15	57	+ 9	36·6	8·0	Es., or. III.
501	—	L. 8078,		19	44	− 68	39·4	6·5	A. C., r.
502	B. 494	3 Cygni,		20	54	+ 24	42·9	6·1	Sch., r. F., o. Es., yw. H., yr. Ch., o.
503	B. 501	. . . . . .		25	30	+ 1	47·4	7·1	Bm., o. Es., o. Ch., golden. V., wy. II.
504	B. 503	β Cygni,		26	17	+ 27	43·7	3·0	Sch., y. Sm., y. W., y. Ch., y.
505	—	+ 30°. 3613,		27	38	+ 30	58·8	8·1	Es., or.
506	—	L. 8154,		27	55	− 24	5·8	6·9	A. C., r.
507	B. 506	+ 5°. 4190,		28	23	+ 5	13·5	6·9	Bm., ro. Es., o. Ch., y. V., wy. II.
508	Es. 327	+ 33°. 3516,		31	58	+ 33	30·6	8·1	Es., or. III.
509	Es. 328	+ 54°. 2178,		35	5	+ 54	42·2	7·5	Es., or. III.
510	Es. 215	+ 34°. 3691,		40	31	+ 34	8·0	7·0	Es., or. III.
511	B. 512	γ Aquilæ,		41	2	+ 10	20·7	3·0	Sch., rr. F., o^1. Es., o^1. Ch., o. V., y. II.
512	Es. 101	+ 40°. 3866,		41	6	+ 40	26·7	6·3	Es., or. III. Ch., rr.
513	—	L. 8221,		42	11	− 47	49·8	6·3	A. C., r.
514	B. 519	19 Cygni,		46	39	+ 38	26·1	5·5	Se., r. D'A., III. F., o^1. Es., o. Ch., o.
515	Es. 251	+ 22°. 3840,		47	45	+ 22	10·4	8·0	Es., r. III. Var.?
516	Es. 107	+ 25°. 4006,		47	47	+ 25	40·8	8·5	Es., or.
517	Es. 385	+ 49°. 3132,		50	38	+ 49	18·3	8·1	Es., or. III.
518	—	L. 8286,		52	47	− 43	20·5	6·7	St., r.
519	B. 522	c Sagittarii,		55	54	− 28	0·9	4·7	Sch., y.
520	Es. 216	+ 51°. 2734,		57	9	+ 51	50·8	7·3	Es., r. III.
521	B. 525	+ 36°. 3820,		57	13	+ 36	47·6	6·7	Bm., o. F., o. Es., o^1. (1885, June 30, 6·5 : Nov. 5, 8·0. 1886, June 27, 7·0 ; var. ?). Ch., o^1.
522	Es. 252	+ 27°. 3612,	xx.	0	16	+ 27	48·7	7·8	Es., r. III.
523	Es. 330	+ 25°. 4097,		1	12	+ 25	17·0	7·8	Es., r. III.?
524	B. 530	+ 16°. 4153,		3	8	+ 16	21·4	6·5	D'A., ry. III. V., ry. III. Du., ry. III. Ch. o.
525	—	L. (8362),		3	58	− 36	22·2	5·8	A. C., r.
526	Es. 331	+ 27°. 3631,		5	9	+ 28	0·0	8·2	Es., or. III.
527	Es. 253	+ 5°. 4436,		5	46	+ 6	1·9	7·9	Es., or. III.
528	—	L. 8367,		5	58	− 52	46·4	6·1	A. C., r.
529	Es. 254	+ 5°. 4441,		6	2	+ 5	45·6	7·8	Es., or. III.
530	B. 537	19 Vulpeculæ,		7	12	+ 26	29·0	5·8	Bm., o. Ch., ro.
531	B. 538	66 Aquilæ,		7	33	− 1	20·3	6·0	Sch., r. W., o^1. F., o. Es., o. V., y. II. Ch., o. K., y. II.
532	Es. 218	+ 49°. 3225,		9	34	+ 49	7·4	8·7	Es., r. III.
533	B. 543	o^1 Cygni,		10	10	+ 46	24·5	4·0	Sch., rr. Sm., o. W., y. F., o. Es., o. Ch., y.
534	—	L. 8388,		11	3	− 48	3·1	6·5	A. C., r.
535	B. 546	23 Vulpeculæ,		11	13	+ 27	28·6	4·8	Bm., o^1. Es., o. Ch., o.
536	B. 547	α^1 Capricorni,		11	33	− 12	50·9	4·5	Sch., y. Ch., y. K., yw. I.
537	B. 548	α^2 Capricorni,		11	57	− 12	53·2	3·8	Sch., y. Ch., y. K., yw. II.? L., ry. ; o.
538	—	L. 8389,		11	58	− 55	23·7	6·6	T., r.
539	B. 549	32 Cygni,		12	5	+ 47	22·6	5·0	Sch., rr. F., o. Es., o. Ch., o^1.
540	B. 550	σ Capricorni,		13	3	− 19	27·7	5·7	W., o. ; *comes* blue ; y ; *comes* r^2. F., o. Ch., y.
541	Es. 219	+ 33°. 3846,		13	37	+ 33	45·0	7·8	Es., or. III.
542	—	+ 38°. 4003,		14	58	+ 38	39·3	6·8	Do., r^3.
543	B. 555	+ 40°. 4141,		18	50	+ 40	40·4	6·0	Bm., o. Es., ro. Ch., ry.
544	B. 557	39 Cygni,		19	28	+ 31	50·1	5·0	Sch., r. F., o. Es., o. Ch., ro.
545	—	+ 7°. 4463,		19	43	+ 7	13·8	8·8	Es., or. III.
546	Es. 386	+ 48°. 3108,		19	46	+ 48	27·3	8·1	Es., or. III. ?
547	B. 560	ω^1 Cygni,		23	40	+ 49	1·1	6·0	Se., y. III, Es., r^1. Ch., y.
548	Es. 256	+ 27°. 3755,		24	25	+ 27	29·1	8·5	Es., or. III.
549	Es. 258	+ 33°. 3922,		25	27	+ 33	28·0	8·7	Es., r. III.

No.	Bm., &c.	Star's Name.	R. A. (1890) Decl.					Mag.	Observations.
			h	m	s	°	′		
550	Es. 222	+ 32°. 3850, .	xx.	27	22	+ 32	12·0	9·0	Es., or. III.
551	Es. 223	+ 32°. 3852, .		27	30	+ 32	7·4	9·1	Es., or. III.
552	B. 563	47 Cygni, . .		29	37	+ 34	52·4	5·4	W., o. Bm., o^1. F., o. Es., o. Ch., o.
553	—	A. G. C., 28222,		30	20	− 65	27·3	7½	T., r.
554	B. 564	70 Aquilæ, . .		31	0	− 2	55·8	5·4	Sch., r. F., o. Es., o. H., or. Ch., o.
555									K., y. II.
556	Es. 259	+ 41°. 3836, .		34	22	+ 41	41·5	7·8	Es., r. III.
557	B. 570	ε Cygni, . . .		41	46	+ 33	33·4	2·6	Sch., y. Bm., y^2. Es., y. Ch., y.
558	Es. 261	+ 27°. 3873, .		43	38	+ 27	50·3	7·9	Es., r^1. III.
559	Es. 121	+ 50°. 3209, .		46	8	+ 50	22·2	7·3	Es., r^1. Ch., r.
560	—	B. 6940, . . .		48	21	− 44	59·6	7½	A. C., r.
561	B. 572	+ 32°. 3980, .		49	26	+ 33	1·2	6·0	Bm., o. W., o. Ch., o. Es., or·^{1}, II.
562	L. I. 38	+ 21°. 4426, .		54	12	+ 21	55·4	7·0	L., r. ; o. Es., or. III.
563	Es. 263	+ 27°. 3952, .		57	42	+ 27	21·7	7·5	Es., r^1. III.
564	—	3 Equulei, . .		59	6	+ 5	3·9	5·5	U. A., r. V., y. II. (?) III. Ch., rr. Es., o^1. F., y.
565	B. 575	24 Capricorni, .	XXI.	0	42	− 25	26·7	4·8	Sch., r. Ch., o.
566	B. 576	ξ Cygni, . . .		0	56	+ 43	29·3	4·0	Sch., r. F., o. Es., o. Ch., y.
567	—	+ 23°. 4253, .		3	31	+ 23	40·0	8·2	Es., or. III.
568	Es. 264	− 6°. 5720, . .		9	15	− 6	0·2	7·0	Es., or. III.
569	Es. 126	+ 62°. 1921, .		14	57	+ 62	27·7	8·7	Es., or.
570	Es. 125	+ 49°. 3499, .		15	1	+ 49	36·3	7·0	Es., or^1. Ch., rr.
571	Es. 127	+ 48°. 3348, .		16	30	+ 48	53·0	8·2	Es., r^2. ; or. III.
572	Es. 265	− 6°. 5743, . .		16	49	− 6	7·5	7·0	Es., or. III.
573	B. 581	33 Capricorni, .		17	55	− 21	19·1	5·3	Chacornac, r. Burton, yw. A. C., r. F. o^1. Gore, r.
574	Es. 184	+ 40°. 4502, .		18	53	+ 40	28·1	7·2	Es., r. III.
575	—	− 14°. 6039, .		23	39	− 14	30·3	7·0	T., r.
576	—	L. (8832), . .		24	5	− 25	40·4	7	A. C., r.
577	B. 583	2 Pegasi, . . .		24	58	+ 23	9·4	4·5	D'A., o. F., o^1. Ch., o. Es., o. III. (?)
578									Du., ry. III.
579	—	Melb. I. 1094, .		34	22	− 68	33·9	7	A. C., or.
580	B. 591	ε Pegasi, . . .		38	47	+ 9	22 3	2·3	Sch., r. Es., o. Ch., o.
581	—	P. 327, . . .		50	24	− 38	10·8	7½	T., r.
582	B. 599	+ 62°. 2007, .		53	33	+ 63	5·7	5·7	Bm., ro. F., o^1. Es., o^2, Ch., o.
583									Du., yr. III.
584	Es. 133	+ 65°. 1691, .		54	24	+ 65	37·7	6·5	Es., or^2. Ch., rr.
585	B. 601	18 Cephei, . .	XXII.	0	39	+ 62	33·8	5·9	Bm., o. Ch., ro. Du., ry. III.
586	B. 602	20 Cephei, . .		1	40	+ 62	14·9	6·0	Bm., o. Ch., o.
587	B. 604	ζ Cephei, . .		7	2	+ 57	39·5	4·1	Sch., r. Bm., o. F., o^1. Es., o. Ch., o^1.
588	—	+ 33°. 4456, .		7	56	+ 34	3·8	5·8	Do., r^1.
589	B. 606	+ 62°. 2048, .		8	56	+ 62	43·5	6·5	Bm., o. Ch., ro.
590	B. 607	. . . .		9	9	+ 39	10·0	4·9	Argel., r. Se., gialla oro, II. ; ro. III. II. Bm., y^1 ; ro. (*comes* 170°). C., o. Burton, r. ; y. Do., y ; r^1. D., o. Es., o. Ch., o^1.
591	B. 608	1 Lacertæ, . .		11	10	+ 37	12·1	4·8	Sch., r. Bm., o. Do., r^1. Es., o^1. III. Ch., y.
592	—	L. 9090, . . .		16	17	− 75	34·3	6½	A. C., r.
593	B. 611	β Lacertæ, . .		19	14	+ 51	40·7	4·7	Bm., o. Es., o. Ch., golden.
594	B. 612	5 Lacertæ, . .		24	57	+ 47	8·7	4·8	Bm., ro. F., o. Es., o. Ch., ro.
595	B. 613	δ Cephei, . .		25	5	+ 57	51·1	var.	Sc., yr. Sm., o. ; y. W., y. C. y. D., o. Es., y^1. Ch., o.
596	Es. 135	+ 56°. 2793, .		26	0	+ 56	25·9	8·4	Es., or. Ch., rr.
597	Es. 136	+ 57°. 2562, .		30	22	+ 57	36·2	7·5	Es., or^3. Ch., rr.
598	B. 615	+ 56°. 2821, .		34	18	+ 56	13·6	6·0	Bm., o. Do., yw. Ch., r^3. Du., ry. III.
599	B. 616	11 Lacertæ, . .		35	40	+ 43	42·1	4·8	Sch., y. B., o^1. F., o^1. Es., y. ; o^1. Ch., r^3.

No.	Bm., &c.	Star's Name.	R. A. (1890) Decl.					Mag.	Observations.
			h	m	s	°	′		
600	—	L. 9224, . . .	XXII.	38	28	– 41	20·6	7·0	A. C., r.
601	B. 618	68 Aquarii, . .		41	39	– 20	31·0	5·4	Sch., y. Pe., o.; spect. cont. Ch., y.
602	B. 620	τ^2 Aquarii, . .		43	46	– 14	10·4	4·0	Sch., r. F., o. Es., o. Pickering, III. (?) Ch., o. K., yw. II*a*.
603	—	+ 40°. 4920, .		44	59	+ 40	26·8	9·1	Es., r. III.
604	B. 621	λ Aquarii, . .		46	53	– 8	9·9	4·2	Sch., r. W., o^1; o. Es., o. Sc., r. Du., ry. III. K., ry. III.
605	B. 622	15 Lacertæ, . .		47	5	+ 42	43·7	5·0	Bm., ro. Do., r^1. F., o^1. Ch., r^2.
606	B. 624	16 Lacertæ, . .		51	22	+ 41	1·0	—	Sm., *comes* r.; 9·5. Es., no colour.
607	—	+ 48°. 3887, .		51	38	+ 49	9·0	4·6	Do., r^1. F., o.
608	Es. 268	+ 32°. 4552, .		52	43	+ 33	7·8	8·0	Es., r. III.
609	L. I. 42	+ 43°. 4375, .		57	10	+ 43	59·3	6·2	L., r.; gold-yellow.
610	—	13 Piscis Aust.,		58	3	– 30	26·9	7·0	T., r.
611	B. 627	β Pegasi, . .		58	26	+ 27	29·0	var.	Sch., r. C. y. Es., o. Se., III. Du., ry. III.
612	B. 629	55 Pegasi, . .	XXIII.	1	28	+ 8	48·9	5·2	Conn. des T., r. D'A., ry. Se., y. II. Bm., or^1.; o^1., ro. C., y. D., o.; or. F., o. Ch., y. V., yr. II.
613	B. 630	57 Pegasi, . .		3	59	+ 8	4·8	5·3	V., ry. III. Bm., o. (*comes* 11). F., o. C., o.; y. D., y; o. Ch., ro. Du., ry. III.
614	L. II. 16	+ 48°. 3952, .		5	16	+ 48	24·7	7·0	L., r. Es., o.
615	B. 632	φ Aquarii, . .		8	38	– 6	38·5	5·0	Sch., r. Bm., o. W., o^1. F., oy. Es., o. Sc., yr. Ch., o. Du., ry. III. K., yw. II*a*.
616	B. 633	ψ^1 Aquarii, . .		10	7	– 9	41·2	5·0	Sch., y. Sm., o.; y. W., y. Es., y. Ch., o. K., wy. II*a*.
617	B. 634	χ Aquarii, . .		11	9	– 8	19·5	5·5	Sch., r. F., o^1. Es., o. Ch., o. Du., ry. III. K., III.
618	B. 635	8 Andromedæ, .		12	38	+ 48	24·9	4·9	Argel., r., Bm. y. C., y. D., o. F., o. Es., o. Du., ry. III. Ch., y.
619	B. 636	94 Aquarii, . .		13	10	– 14	3·4	5·3	Sm., r^1; o. Σ., wy. Demb., y. Sadler, o^1. W., y. Pe., r.; spect. cont. Ch., o. K., wy.; II*a*.
620	L. II. 17	+ 40°. 5066, .		18	53	+ 41	1·2	6·5	L., r. Es., o.
621	Es. 141	+ 48°. 4051, .		21	46	+ 48	54·6	9·3	Es., or.
622	B. 644	λ Andromedæ, .		32	11	+ 45	51·7	3·5	Sch., y. Ch., y.
623	—	L. 9589, . . .		40	58	– 56	25·3	7½	T., r.
624	—	+ 20°. 5386, .		46	49	+ 21	2·9	5·8	Do., r^1.
625	B. 651	. . . .		47	0	+ 74	55·0	6·3	Racl. obs., o. Se., y. o.; III. Bm., yr. C., o. Ch., o^1.
626	B. 652	ρ Cassiopeiæ, .		48	53	+ 56	53·2	5·0	Sch., r. Ch., y.
627	B. 654	L. 9659, . . .		51	28	– 27	14·3	6·4	Hist. Cél., r. Se., y.; spect. cont. Pe., y^2.; spect. cont. Ch., r^2. Bm., r^1.
628	B. 655	ψ Pegasi, . . .		52	9	+ 24	31·9	4·3	Sch., r. Do., y^1. Es., o. Ch., ry.
629	—	L. 9680, . . .		54	5	– 25	15·4	7½	A. C., or.

STARS WITH BRIGHT LINES IN THEIR SPECTRA.

Although these objects are not, with certain exceptions, red, yet from their great rareness, Mr. Birmingham included them in his Red Star Catalogue. Since the first Edition several new ones have been discovered, and a new type, which I have ventured to call, for the sake of distinguishing it from the others, III*c*.

The stars with bright lines have been divided by Dr. Vogel (*Spect. Beob.*, p. 123) into classes, as follow:—

I*a*. The rays of hydrogen and D_3 are bright (γ Cassiopeiæ, β Lyræ).

II*b*. Besides dark rays and isolated bands, there are bright lines (the Nova Andromedæ, and the stars of Wolf and Rayet in Cygnus).

To these may be added the new type:

III*c*. Some of the rays of hydrogen and D_3, and other bright lines, occur in addition to the third type spectrum, and the stars are variable.

The following are the places of all the stars with bright lines discovered up to the present date:—

No.	Name.	R. A., 1890.	Precess.	Decl., 1890.	Precess.	Mag.	Type.	Discoverer.
		h m s	s	° ′	′			
1	R Andromedæ, .	0 18 13	+ 3·15	+ 37 58·1	+ 0·33	Var.	III*c*.	Espin.
2	Nova (1886), .	36 43	3·25	+ 40 39·9	0·33	Var.	II*b*.	Copeland.
3	γ Cassiopeiæ, .	50 4	3·57	+ 60 7·3	0·33	2·3	I*c*.	Secchi.
4	S Cassiopeiæ, .	I. 11 35	4·34	+ 72 2·0	0·32	Var.	III*c*.	Espin.
5	φ Persei, . . .	I. 36 46	3·72	+ 50 8·1	0·31	4·1	I*c*.	Pickering.
6	Mira Ceti, . .	II. 13 47	3·03	− 3 28·6	0·28	Var.	III*c*.	Pickering.
7	Pleione, . . .	III. 42 38	3·56	+ 23 48·2	0·19	—	I*c*.	Pickering.
8	Ll. 9051, . .	IV. 43 10	2·94	− 5 51·6	0·11	6·3	I*c*.	Konkoly.
9	U Orionis, . .	V. 49 17	3·56	+ 20 9·2	0·02	Var.	III*c*.	Copeland. Pickering.
10	Ll. 13412, . .	VI. 49 22	2·50	− 23 47·0	− 0·07	—	II*b*.	Pickering.

No.	Name.	R. A. 1890.			Precess.	Decl., 1890.		Precess.	Mag.	Type.	Discoverer.
		h	m	s		°	′	′			
11	R Geminorum, .	VII.	0	44	+3·62	+ 22	52·7	0·09	Var.	III*c*.	Vogel.
12	γ Velorum, . .	VIII.	6	8	1·85	− 47	0·8	0·17	Var.	I*c*.	Respighi.
13	. . . .		51	15	2·01	− 47	9·6	0·23	8·8	II*b*.	Copeland.
14	R Leonis, . .	IX.	41	39	3·23	+ 11	56·3	0·28	Var.	III*c*.	Espin.
15	. . . .	X.	37	10	2·31	− 58	10·2	0·31	9·8	II*b*.	Copeland.
16	η Carinæ, . .		40	48	2·31	− 59	6·4	0·31	Var.	I*c*. ?	Le Sueur.
17	. . . .	XI.	5	37	2·52	− 60	23·3	0·32	9	II*b*.	Copeland.
18	Ll. 21697, . .		18	14	3·03	− 9	49·1	0·33	8·2	I*o*.	Konkoly.
19	69 Virginis, . .	XIII.	21	35	3·20	− 15	24·2	0·33	5·5	I*o*.	Konkoly.
20	R Hydræ, . .		23	42	3·27	− 22	42·7	0·31	Var.	III*o*.	Espin.
21	. . . .		46	5	4·41	− 65	58·6	0·33		II*b*.	Copeland.
22	T Coronæ, . .	XV.	54	54	2·51	+ 26	13·0	0·17	Var.	III*c*.	Huggins.
23	P. 202, . . .	XVI.	46	27	4·20	− 41	38·5	0·11	7½	II*b*.	Copeland.
24	O. A., 17681, .	XVIII.	1	54	3·59	− 21	16·1	+0·00	7·8	II*b*.	Pickering.
25	D. M., +8°. 3780,		33	6	2·87	+ 8	44·0	0·05	Var.	III*o*.	Espin.
26	β Lyræ, . . .		46	1	2·21	+ 33	14·1	0·06	Var.	I*c*.	Secchi.
27	R Cygni, . .	XIX.	33	52	1·61	+ 49	57·1	0·13	Var.	III*c*.	Espin.
28	χ^1, 17, Cygni, .		42	16	2·27	+ 33	28·6	0·14	5.4	I*o*.	Becker.
29	χ^2, Cygni, . .		46	20	2·31	+ 32	38·2	0·15	Var.	III*o*.	Espin.
30	D. M., +35°. 3952,	XX.	1	48	2·25	+ 35	21·4	0·17	7·5	II*b*.	Wolf & Rayet.
31	D. M., +35°. 4001,		6	8	2·25	+ 35	51·2	0·17	8·5	II*b*.	Wolf & Rayet.
32	D. M., +35°. 4013,		7	46	2·25	+ 35	52·2	0·17	8·0	II*b*.	Wolf & Rayet.
33	D. M., +37°. 3821,		8	6	2·19	+ 38	1·6	0·18	7·1	II*b*.	Copeland. Pickering.
34	D. M., +36°. 3956,		10	25	2·24	+ 36	19·6	0·18	8·0	II*b*.	Pickering.
35	D. M., +36°. 3987,		12	55	2·23	+ 37	5·0	0·18	8·1	II*b*.	Pickering.
36	P Cygni, . . .		13	43	2·21	+ 37	41·3	0·18	Var.	I*o*.	Pickering.
37	D. M., +38°. 4010,		15	30	2·19	+ 38	23·1	0·19	8·7	II*b*.	Pickering.
38	D. M., +43°. 3571,		16	48	2·05	+ 43	30·6	0·19	7·5	II*b*.	Pickering.
39	Nova (1876), .	XXI.	37	23	2·36	+ 42	30·4	0·27	Var.	III*c*.	Cornu.
40	R Cassiopeiæ, .	XXIII.	52	49	3·01	+ 50	46·5	0·33	Var.	III*c*.	Espin.

No. 1, R Andromedæ.—On Sept. 25, 1889, the F line appeared of extraordinary brilliancy. Near D_3 there seemed to be several bright lines. The brilliancy of the F line was so remarkable that it appeared to project beyond the spectrum. In addition to the usual third type spectrum a large band was seen in the violet. The weather was too unfavourable to allow further observations till Oct. 17, when the star had greatly diminished in brightness, and the F line was not certainly seen, and had evidently faded out much faster than the other parts of the spectrum. On Sept. 30, Mr. Maunder (private letter) obtained a glimpse of the star between the clouds, and saw F "blazing," as he well describes it. On Oct. 19 a rough measure gave for the two bright lines 487·3 and 513·2. "The change," he adds, "from the glimpse I got on Sept. 30 was very striking." Dr. Becker (private letter) was unable to obtain observations at Dunecht till Oct. 29, and from a rough reduction of the measures found an "extremely bright line at 486·3; therefore F and a very bright line in 494·2, besides many bright lines between F and D. Near D (without knowing the position of D_3), a bright line in 584·4, and another one in 587·7 (the wave length of D_3 is 587·47)." Considering that Dr. Dunér made a special study of this star, having observed it six times in 1882, and on several nights in Jan., 1885, with the spectroscope, and never saw even F, it seems highly probable that the phenomenon of the bright lines is temporary, as in the case of R Cygni. Although, probably, the lines always remain bright, yet at certain periods they flash up with extraordinary brilliancy.

No. 2.—Dr. Copeland (M. N., XLVII., p. 50), found the star, on Sept. 1, yellowish; and, viewed through a prism held between the eye and the eye-piece, the first glance showed that the spectrum had little or nothing in common with the brilliant spectrum of Schmidt's Nova Cygni in its earlier stages. The spectrum was continuous from end to end, and only on close examination could slight condensations, indicative of bright lines, be detected. The spectrum was not considered to differ strikingly from that of the nebula. On Sept. 10, the spectrum was found to extend from 670 to 453. With a spectroscope of higher dispersion a maximum was found at 544·4, and a "suspicion of a bright line, but hardly more," at 482·2. On Sept. 11, the spectrum appeared *quite continuous*, but, on Sept. 13, again showed traces of bands, and was slightly banded on the 15th. Traces of condensation of light were seen at 471·6, on Sept. 20. At the end of September a special acute prism of only 15° was used, and it was concluded that there were three bright bands at 546·8, 514·0, 489·0. Dr. Copeland remarks that the spectrum described is the same as that given by any hydrocarbon flame burning so feebly that the spectrum of the blue base of the flame is just beginning to show through the continuous spectrum afforded by the white part of the flame (*ibid.*, p. 55).

γ Cassiopeiæ, No. 3, β Lyræ, No. 26, show all the hydrogen lines and D_3, but all observers agree in the variation of these lines, and Dr. Gothard finds periodic variation. Mr. Maunder believes that they do not vary simultaneously, and in the same manner. Dr. Becker (private letter), on Aug. 8, 22, 23, 25, 31; Sept. 3, 6, 15, 16, 17, 19, 20, found in γ Cassiopeiæ, C extremely bright; F not brighter than other bright lines in that region; γ Hydrogen visible. "Several times," he says, "I marked in the note-book there must be a great many bright lines in the yellow and green."

No. 4, S Cassiopeiæ.—The star was observed, 1889, Nov. 28, when only a little above 8 mag. The spectrum is III. ! ! !, but with F as brilliant as in R Andromedæ. The star should have been at a maximum on Dec. 25; but subsequent observations showed that the star was probably past its maximum on Nov. 28. Mr. Grover (private letter) fixes the maximum at Nov. 20th.

No. 5, φ Persei.—The bright lines were detected by Pickering by photography. The star was observed by me, 1889, Oct. 17, when the F line was easily seen.

Mira Ceti.—Although this star has been repeatedly observed with the spectroscope, Pickering was the first to call attention to the bright lines. One of his photographs, taken with three hours' exposure, shows no less than six bright lines, including γ and δ of hydrogen, and forty-seven dark lines; another photograph, taken at an earlier date (?), shows no signs of the γ and δ hydrogen lines, although the other bright lines are visible. A drawing accompanies my own observations of Oct. 23 and 30, 1888 (M. N., XLIX., No. 1, p. 18). The γ hydrogen line was easily seen, and the Band 8 was found to be double, while No. 9 was found to be broken up into at least two, and No. 10 into three, which is also shown in Pickering's photograph. The γ line was measured line by Maunder, but neither F nor D_3 were seen.

No. 7.—Pickering (A. N., 2934), and private letter.

No. 8.—Ll., 9051, was observed by Dr. Konkoly, 1883, Nov. 28 and Dec. 22, as "6 mag.; once C and then, C and F believed bright."

No. 9, U Orionis.—On December 17, 1885, Dr. Copeland found the spectrum to be an especially beautiful one. On December 17, it was observed with a powerful compound prism. The following bright lines were observed (M. N., xlvi., No. 3, p. 110):—

Almost a bright line,	584·1
Very bright line, beginning of bright band,	516·2
Second bright line,	513·7
Bright line, beginning of band,	494·4
Second bright line,	492·3
Bright line; fairly visible,	477.8
Isolated bright line just discernible,	
Bright line; fairly visible,	472·2

A sketch is given, showing the relative degree of brightness of the various parts of the spectrum. Dr. Copeland comes to the conclusion that the star shows *a not very luminous spectrum upon which a series of bright bands are superposed*, and finds evidences of a spectrum of hydrocarbon. Mr. Maunder observed no bright lines, and disputes Dr. Copeland's conclusions, neither could M. Wolf see them; but Pickering, by photography, finds a similar spectrum to that of Mira Ceti.

No. 10, Ll., 13412.—A photograph of this star is given in Vol. xi., No. 4, *Mem. of the American Academy*, Plate iii., No. 5. The negative shows in all twelve bright lines.

No. 11, R Geminorum.—An account of the spectrum of this star has already been given (p. 125).

No. 14, R Leonis.—γ Hydrogen and D_3 were believed bright, 1889, March 9, and Mr. Taylor confirmed them, and suspected the existence of F (private letter).

No. 18, Ll., 21697.—Dr. Konkoly found C, and probably D_3, bright, 1885, April 19.

No. 19, 69 Virginis.—Dr. Konkoly believed C, D_3, and F bright, with averted vision, 1884, May 18.

No. 20, R Hydræ.—The spectrum was found to be similar to Mira, 1889, Feb. 25, and this was confirmed by Mr. Taylor.

No. 22, T Coronæ.—On May 12, 1886, Dr. Huggins found a third type spectrum, with the addition of bright hydrogen lines and D_3; the star has diminished to an irregular variable, and, according to Lockyer (*Nineteenth Century*, Nov., 1889), now shows a nebula-spectrum.

No. 25, D. M. + 8°. 3780.—Nov. 17, 1889, star about 7 mag.; spectrum probably similar to Mira, but star low. γ Hydrogen and D_3 pretty certain.

No. 26, β Lyræ.—Maunder (M. N., XLIX., No. 5, p. 303), finds that, in the case of γ Cassiopeiæ, the bright lines do not vary simultaneously, but in the case of β Lyræ, the observations are not inconsistent with a simultaneous variation of all three lines (C, F, D_3) observed. He also finds that the yellow line in β Lyræ is really the D_3, and not the fluting of manganese. His observations seem to be not inconsistent with the supposition that the D_3 line varies in a periodic manner, a maximum brightness occurring soon after the secondary minimum of the star, followed by a decline to a minimum after the second maximum of the star. He also, on one occasion, suspected that C and F were represented by dark lines. Dr. Becker (private letter), from Sept. 6–22, made 560 observations of the lines in this star, and believes that there are over one hundred different bright lines.

No. 27, R Cygni.—On August 13, 1888, a very bright line, apparently F, was seen in this star. The third-type spectrum, which had been previously observed by Dunér, was not certainly seen. Dr. Copeland measured the bright line and found it to be certainly F, and believed the spectrum to be third type (private letter). Mr. Maunder (M, N., XLIX., No. 5, p. 306), on Sept. 21, found bright lines near D_3 and F, and on Oct. 1, only F was seen. He adds, that "the general spectrum of the star, apart from the bright line at F, appeared to be that of Secchi's fourth type, viz. one crossed by shaded dark bands, which are sharp and dark in their less refrangible side, and shade off towards the violet." Before the next maximum it was observed, on 1889, Sept. 16, by me, when it was 7·5 mag., and found to be obviously third type; but the F line was not certainly seen, and if bright at all, very different to last year. But on Oct. 28, Dr. Becker (private letter) found a very bright line in 486·1 (therefore F), almost as bright as in R Andromedæ. He adds, "that there are many bright lines in the green, but I measured only 9. A very faint line, almost at the end of the visible spectrum, was observed in 584·4."

No. 28, χ^1 17 Cygni.—Observed by Dr. Becker from June 3 to July 26, 1888, on eleven nights, 457 observations, 74 bright lines. "C and F, probably not amongst them, although there are two lines near F, viz. 486·9 and 485·0, but not brighter than the neighbouring lines. Near C are two lines, 660·1 and 651·8; near D, 596·8, 593·9, 590·7, 587·2, 583·2, 580·6. The 587·2 line was the brightest in that part on June 10; after that date I thought the line at 590·7 was the brighter" (private letter).

No. 29, χ^2 Cygni.—On May 19, 1889, γ Hydrogen was seen, and D_3 was remarkably bright. The observations were confirmed by Mr. Taylor.

Wolf's and Rayet's Stars in Cygnus (Nos. 30, 31, 32).—Type IV., but with irregular zones. Each of the three stars has a pretty bright line in the blue, and a bright group in the green yellow, the interval being occupied by a faint continuous spectrum. The second group, however, is not identical in the three stars. In star No. 2 (No. 31) in the order of R. A., this group appears to be composed of three bright lines. The principal bright line does not seem to be the F of Hydrogen; it appears to coincide with the third line of the same colour in stars of the IV. type. Compared with a red star of the IV. type in Ursa Major, there appeared the following results:—

1st star:—The two principal lines agreed with those in the star of comparison; in the interval no distinct lines, but a continuous spectrum; type IV., but deficient in the green.

2nd star:—The blue line more toward the violet; the yellow is multiple; bright zones in the interval, but too faint to be determined.

3rd star:—Similar, but more difficult to be observed, on account of the adjacent star, which disturbs the spectrum. It is noteworthy that three stars of the same extraordinary type are found so near each other. Their colour is yellow orange, and they belong to a variety of the fourth type, in which carbon is prominent. It will be understood that, on account of the difficulty of observation, the position of the lines was found only approximately, and that an object-glass of only nine inches is not sufficient to deal with them.

5th July, 1870: compared with Schj. 152, lines in the yellow or the 2nd star seemed to coincide; also the lines in the blue. Another line appeared between the two bright ones. In the 1st star, a bright yellow line coincided. Nothing else seems definite in Secchi's account of this star.

He says, however, that there was enough seen to fix the type. The 3rd star showed the same type, but more difficult to be observed on account of adjacent stars; the F line not identified. On July 7th the 1st star showed really two bright lines, and it must be of type IV. The bright line in the blue fell outside F, and is probably of carbon. The 2nd star had three lines in the yellow, a faintly luminous space in the green, and a brilliant one beyond the blue. This also belongs to type IV. The 3rd had a continuous spectrum, a little brighter and more extended, but it agrees with the other two.—*Sugli Spettri*, &c., 1872; pp. 18, 19.

Dr. Vogel, in the *Astr. Nachr.*, No. 2000, remarks that these stars must be reckoned, on account of their spectra, among the most interesting objects in the heavens. In a faint continuous spectrum, with some dark bands, appear brilliant lines which coincide neither with D_3 nor with the lines of hydrogen, as they do in β Lyræ and γ Cassiopeiæ. In each spectrum of the three stars he repeatedly found four lines, and determined their positions. He altogether denies any resemblance among these spectra to the fourth type, and finds no evidence of carbon.

Nos. 33, 34, 35, 37, 38 are similar to those of Wolf and Rayet, No. 33 being the finest. The grouping of so many of these stars and so many of the IV. type together is very remarkable.

No. 36, P Cygni. The photograph of Professor Pickering shows six bright lines. The lines shown are γ Hydrogen, G, h, a line more refrangible than h, H, and a line more refrangible than K, and which is apparently identical with one of the bright lines in Mira Ceti, and with a bright line in β Lyræ. The F line has been measured by Mr. Taylor and Mr. Maunder. It is very conspicuous: on one occasion I saw a line more refrangible than F.

No. 38. This star is remarkable for its colour, which is deep yellow.

Nova, 1876. Mr. Birmingham gives the following account of the spectrum of this star:—

SPECTRUM OF SCHMIDT'S NEW STAR IN CYGNUS.

M. Cornu, of the Paris Observatory, was the first who examined the spectrum of the new star when it was between 5 and 6 magnitude, and showed a bright line spectrum indicative of incandescent gas. The three bright lines of hydrogen were seen—C, F, and a line with wave length 434. The D of sodium was also present; *b* of magnesium, and two of W. L. 535 and 503. The first of these appeared to coincide with Kirchhoff's 1474 observed in the Sun's corona, which leads one to believe that perhaps the ray appearing to correspond with sodium might belong, in fact, to the solar element called helium.—*Nature*, No. 372, vol. 15.

Dr. Vogel found the star yellow red, and the spectrum one of the most interesting that he knew, crossed by some eight to ten dark bands and several bright lines. Among the latter was a remarkable one in the extreme red, then one on the borders of the blue and the green, and two in the blue. One of the bright lines was found by measurement to be the F line of hydrogen, and the red line was determined to be C of that gas. In the following Table the two columns show the extremes between which lie the true measures of the lines:—

587–589, . . .	Bright line.
469–470, . . .	Bright streaks, possibly bright lines.
526–528 (E), . .	" " "
513–514, . . .	" " "
507–509, . . .	" " "
497–499, . . .	" " "
485–486 (F), . .	Bright line.

Hence it is apparent that, besides the hydrogen lines C and F, the line D_3—W. L. 487·5 [? 587·5]—was bright in the spectrum. The magnesium lines *b* were not seen as bright lines, but a bright line rather more refrangible than *b* was repeatedly measured, and this might, possibly, be identical with the brightest line that, under special circumstances, appears in the spectrum of carburetted hydrogen. A line in the violet shone out at intervals apparently the third hydrogen line near G. This star, along with Wolf's and Rayet's three stars in Cygnus, makes up four in a small space of the heavens with spectroscopic features different from any among several hundred spectra hitherto examined.—*Astr. Nachr.*, No. 2115.

Dr. Copeland, at Lord Lindsay's Observatory at Dunecht, observed the star on Jan. 2 with the 15-inch refractor, when it appeared about 7 magnitude and of a decided red colour. The spectrum, as shown in a spectroscope of Dr. Vogel's construction, was of surprising brilliancy, continuous, and with five bright lines, the positions of which in wave-lengths were as follows:—

No. 1.	W.L.,	655,	Intense bright red.
„ 2.	„	581,	Middle of a rather bright band in the yellow, fading off rapidly on both sides.
„ 3.	„	504,	Bright, well-defined line.
„ 4.	„	486,	„ „ „
„ 5.	„	456,	Faint line in the violet.

Nos. 1 and 4 are obviously the C and F lines of hydrogen; No. 3 coincides almost exactly with the brightest line of gaseous nebulæ; and, lastly, No. 2 corresponds very nearly with one of the bright lines of the three remarkable stars in the Swan pointed out by Messrs. Wolf and Rayet, and subsequently observed by Dr. Vogel.—*Astr. Nachr.*, No. 2116.

There remains Father Secchi's account, according to which the star appeared on Jan. 8, of a greenish colour, tending to yellow, and 7–8 magnitude. The spectrum showed two strong lines, one of which agreed with hydrogen, and the other with magnesium. The sodium also was well defined and bright. A line in the violet was probably another of hydrogen; the red of that gas was too faint for measurement. Besides these four fine rays, there was a multitude of small rays between D and magnesium; but the space in which were the two brilliant lines of magnesium and the hydrogen F was nearly devoid of any light. After these two brilliant lines toward the violet there was a black lacuna, and then a succession of very fine lines. M. Cornu's description is therefore exact, only that the bright rays show no nebulosity at the borders, but are perfectly well defined like the bright lines of the nebulæ.—*Astr. Nachr.*, No. 2116.

On Jan. 9, the next day after Father Secchi's observation, Dr. Copeland again examined the spectrum, and, in addition to the five lines that he saw on the 2nd, he now found two others, as follows :—

No. 1*a*, W. L. 594, . . Very narrow line.
„ 7, „ 414 ±, . . Excessively faint, but still certainly and repeatedly seen.

Between wave-lengths 655 and 594 the spectrum was certainly banded, and there were, most probably, two additional faint maxima of brilliancy in that interval. The continuous spectrum attains a maximum in the region about W. L. 525, and extends, though possibly not without interruption, as far as the faint line No. 7. The star was of the 7th magnitude, and of a red colour, with a decided tinge of purple, like a variety of red produced by the quartz plate in Zöllner's photometer.—*Astr. Nachr.*, No. 2117.

To this account should be added that at Dunecht, on Sept. 2, 1877, the star showed the spectrum of a gaseous nebula, the light being confined to the bright line at 500. In 1880, however, Pickering found there was, again, a continuous spectrum. In November, 1889, I endeavoured to observe the star with the spectroscope, but it was too faint.

No. 40, R Cassiopeiæ, 1889, Sept. 25.—Occasionally D_3 and γ line of hydrogen were suspected bright, but not F.

In conclusion, we have evidence to lead us to suspect—

(1) That in stars of type I*c*, where the hydrogen lines are bright and D_3, the lines vary, and this variation is not simultaneous.

(2) That in stars with type III*c*, one or more of the hydrogen lines may be brilliant, and the others invisible, as in Mira, where γ and δ were conspicuous, but there was no trace of C and F.

(3) In the case of R Andromedæ, R Cygni, and S Cassiopeiæ, the extremely brilliant line F was detected *after* the maximum.

(4) In Vogel's type, I*b*, the hydrogen lines may really be faintly bright, and in one of the stars of this class the existence of other bright lines is proved, and they will hence, probably, be found in others.

ADDED IN THE PRESS.

The following additional stars have been found by Pickering (A. N., 2934) to have bright lines, from the photographs taken by Messrs. Baily, in Peru :—

		h	m	s	s	°	'	'		
14*a*	L. 4422, .	X.	37	5	+ 2·28	− 59	6·1	− 0·31	7½	II*b*
15*a*	L. 4448, .		39	39	2·29	− 59	32·4	− 0·31	6·9	II*b*
16*a*	L. 4612, .	XI.	1	56	2·35	− 64	54·9	− 0·32	8¼	II*b*
18*a*	δ Centauri,	XII.	2	40	3·08	− 50	1·6	− 0·33	2·8	I*c*
18*b*	θ Muscæ, .	XIII.	1	1	3·80	− 64	43·0	− 0·32	6	I*c*
18*c*	μ Centauri,		43	0	3·59	− 41	55·5	0·30	3·4	I*c*
22*a*	L. 7000, .	XVI.	43	53	4·17	− 41	2·4	0·11	5·9	II*b*
22*b*	P. 188, .		44	36	4·19	− 41	40·0	0·11	7½	II*b*
23*a*	L. 7029, .		47	18	4·17	− 40	58·2	0·11	6·4	II*b*
23*b*	L. 7099, .		56	21	4·07	− 37	59·6	0·09	6·5	II*b*
23*c*	L. 7101, .		56	29	4·06	− 37	41·2	0·09	7·1	II*b*
23*d*	L. 7209, .	XVII.	11	25	4·40	− 45	31·3	0·72	7½	II*b*

The photographs confirm the bright lines in η Carinæ, and Nos. 17, 23 and R Hydræ.*

The discovery of these additional stars brings out the fact that there are two great groups of II *b*, one in Cygnus and one in Scorpio, situated at each end of the bifurcation of the Milky Way.

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* Mr. Taylor and Dr. Huggins find that some of the stars in the Orion Nebula have bright lines, and the Lick observers believe that U and V Cygni also have bright lines.

CONCLUDING NOTE AND ADDENDA.

The total number of stars contained in the Catalogue is 1472, of which 766 are in the Red Star Catalogue, 629 in the Additional List of Ruddy Stars, and 77 in the Addenda. Besides these there are 52 stars with spectra of bright lines.

The Number of Stars of Different Colours.—Professor Pickering (Annals of the Harvard College Observatory, vol. XIV., pt. II., p. 483), gives the following formula for computing the theoretical number of stars brighter than some limiting magnitude M.:—

$$\text{Log. } n = {\cdot}52 \text{ M} + {\cdot}54.$$

The white, yellow, and red stars will then be represented by $n \times n'$, $n \times n''$, $n \times n'''$, respectively, where n', n'', n''' represent decimal quantities, the sum of which is unity. The most complete zone observations of stars down to a definite magnitude are those of Vogel in the *Spect. Beob.*, which contains all the stars down to mag. 7·5 within the limits of − 1° and + 20°. A less complete series is given by Konkoly, in a similar work, from − 0° to − 15°. Lastly, there are the colour observations of Mr. Franks. In order to obtain some approximate values for the quantities n', n'', n''', the stars given by Vogel and Konkoly for each magnitude were counted and arranged according to their colours. The variable stars and the double stars were rejected, also the stars below 7·5 in Vogel's observations, and the colours divided into three classes: n', includes white, yellowish white, whitish yellow; n'', yellow and reddish yellow; n''', yellowish red and red. In the case of Konkoly's observations a curious colour equation appears, for, adding the numbers of reddish yellow and yellowish red stars together, it was found that 0·15 were reddish yellow and 0·85 yellowish red, or the red were nearly six times more numerous than the orange. Of the yellowish red stars five have also been observed in the *Spect. Beob.* of Vogel, who makes three yellow, one whitish yellow, and one reddish yellow. Moreover, of the fourth type stars, which are certainly red, Konkoly makes three out of four reddish yellow only. It seems therefore probable that the colour equation may be elimated by substituting one for the other, and this has, accordingly, been done in obtaining a value for n'''. In Mr. Franks' observations all the stars that are white, or which have a qualifying adjective, such as greenish, bluish, &c., and also the pale yellow stars have been included under n', the yellow, the orange, and red orange under n'', and the orange red and red under n'''. The following Table gives the results so obtained, the first column containing the observer's name, the next three the values of n', n'', n''', the fifth the total stars counted, the sixth, seventh, and eighth the differences between the numbers observed and calculated. The probable value was computed by the formula:

$$\text{Probable value} = \frac{5\,V + 2\,K + 3\,F}{10}.$$

Where V, K, F are the values of n', n'', n''', found from Vogel, Konkoly, and Franks' observations, respectively:—

TABLE I.

Observer's Name.	n'	n''	n'''	Total Stars.	C – O.	C – O.	C – O.
Vogel, . . .	0·7836	0·2069	0·0095	3775	– 168	+ 154	+ 14
Konkoly, . .	0·8285	0·1661	0·0054	1989	– 186	+ 235	– 3
Franks, . .	0·6644	0·3300	0·0056	2845	+ 179	– 182	+ 3
Probable value,	0·7568	0·2357	0·0075	—	—	—	—

Making use of the value of n''', we are now in a position to discuss the results obtained from the Red Star Catalogue. In the following Table the first column gives the magnitude, the second and third the number of stars N. and S. of the equator, the fourth, the total number of stars *above any given magnitude* in column 1, and including that magnitude, the fifth, the numbers obtained by using the value of n''' found in the preceding Table, the sixth, the difference of the last two columns.

TABLE II.

Magnitude.	N.	S.	Total.	Calculated.	C – O.
0–1	0	1	1	0	– 1
1–2	0	0	1	0	– 1
2–3	0	3	4	1	– 3
3–4	0	5	9	4	– 5
4–5	8	12	29	15	– 14
5–6	21	24	74	46	– 28
6–7	76	83	233	153	– 80
7–8	94	73	400	507	+ 107
8–9	116	90	606	1679	+ 1073

It is obvious from column six that the Catalogue exceeds in stars above 7·5, and is deficient below 7·5. The excess in the brighter stars is probably due to a tendency to overrate the redness of stars, and this will occur more especially in casual observations of colour, such as in stars detected in meridian observations, while deficiency is probably in some measure due to the fact that the assumed value of n''' is really too large. That there cannot be so many really red stars is shown conclusively by the result of the sweeps for red stars made from 1885 to 1889. In the following Table the number of new ones, north of the equator, found in each year is given, with the exception of 1885–86, which have been combined in one column, the work being only carried on at intervals during these years:—

TABLE III.

Magnitude.	1885–86.	1887.	1888.	1889.	Total.
5–6	0	0	0	0	0
6–7	2	4	0	0	6
7–8	14	17	5	3	39
8–9	16	25	10	4	55
Below 9	7	14	7	4	32
	39	60	22	11	132

The Number of Stars of the Four Types of Spectra.—Dr. Dunér has already investigated the values for the third and fourth types, and finds that these numbers may be expressed by $n \times 0{\cdot}0888$ for the third, and $n \times 0{\cdot}0018$ for the fourth type. In order to obtain fresh values for these, and also for the first and second types, the zones of Vogel and Konkoly were used, when the following quantities were obtained, the number of fourth type stars found by Vogel being corrected by Dunér's observations and by my own. The probable value was obtained by the equation:—

$$\text{Probable value} = \frac{6\,V + 4\,K}{10}.$$

TABLE IV.

Observer's Name.	I. Type.	II. Type.	III. Type.	IV Type.	Total Stars.
Vogel, . . .	0·5848	0·3349	0·0787	0·0016	3702
Konkoly, . .	0·5225	0·4327	0·0434	0·0014	2005
Probable value,	0·5599	0·3740	0·0646	0·0015	—

It will be seen that these values are 0·0242 less for the third type, and 0·0003 less for the fourth than those of Dunér.

In conclusion, my thanks are due to Dr. Becker, Dr. Copeland, Mr. Maunder, Mr. Taylor, and Mr. W. Wesley for much valuable assistance, especially in the preparation of the section on the stars with bright lines in their spectra. As the proofs have been received a re-examination of the places of the stars has in many cases been made, and the precessions recalculated. Several misplacements occur, some through clerical errors, others through altogether new places having been obtained. It has been thought better to leave the stars as originally numbered, rather than cause a wholesale disturbance of type, more especially as the errors are small, and the Catalogue can only be considered as provisional.

The Addenda consists of stars accidentally omitted, or else detected since the fair copy of the MS. was made.

ADDENDA.

No.	Star's Name.	Right Ascension (1890).			Precession in R. A.	Declination (1890).		Precession in Decl.	Mag.	Observations.
		h	m	s	s	°	′			
10*a*	D. M. – 4°. 51, .	0	23	52	+3·06	– 4	5·7	0·33	7·4	Konkoly; 1883, Oct. 31, Nov. 23, gelblich roth; 7; III. (?)
10*b*	D. M. – 3°. 57, .		24	1	3·06	– 3	26·7	0·33	7·1	Konkoly; 1883, Oct. 31, Nov. 23, gelblich roth; 7; II*a*.
10*c*	. . . .		27	9	3·24	+ 47	53·5	0·33	neb.	Earl of Rosse (Neb. Obs., p. 9); note on G. C., 72. 1851, Nov. 24, neb. f. ruddy 9–10, about 45′, and a little n.
11*a*	D. M. + 81°. 18, .		41	11	4·64	+ 81	22·0	0·33	7·6	Knott (private letter); red and variable.
25*a*	. . . .	I.	21	3	3·08	+ 1	26·9	0·31	neb.	Earl of Rosse (Neb. Obs., p. 19); note on G. C., 326. 1876, Oct. 23, orange red; 9·10 (with a faint companion, ¾′ p.); 25ˢ 9 f. 386″·0 n.
54*a*	D. M. + 59°. 530,	II.	33	4	4·46	+ 59	14·9	0·26	8·2	Espin; No. 300. 1888, Dec. 26, very red; 8·8; deep bands, probably III. type.
54*b*	. . . .		34	56	3·83	+ 42	18·4	0·26	neb.	Earl of Rosse (Neb. Obs., p. 31); note on G. C., 584. 1872, Oct. 13, an isosceles triangle of stars on the n. side points s. to a red star, which has a small companion s. p.
81*a*	37 Eridani, . .	IV.	5	1	2·92	– 7	13·7	0·16	4·4	Konkoly; 1883, Aug. 23, Sept. 10, gelblich roth; 6 mag.; II*a*.!
82*a*	D. M. + 49°. 1136,		6	36	4·44	+ 49	12·6	0·16	8·8	Espin, No. 305; 1888, Oct. 3, red; bands; type uncertain.
82*b*	. . . .		6	53	4·52	+ 50	57·6	0·16	neb.	Earl of Rosse (Neb. Obs., p. 40); note on G. C., 820. 1872, Oct. 13, 30′, s. f. is a very red 9½ mag. 1875, Dec. 4, about 2 m. f. and 12′ ± s. is a very red 9–10 mag.
88*a*	. . . .		20	25	5·62	+ 64	36·1	0·14	neb.	Earl of Rosse (Neb. Obs., p. 41); note on G. C., 847. Has an 11 m. reddish, pos. 359°·0; dist. 45″·0; the s. member of a double star.
108*a*	D. M. + 12°. 695 ?		53	21	3·36	+ 12	39·6	0·95	8·4	Chambers (M. N., XLVII., No. 6), No. 95; 8¾; decided red. Position approximate.
116*a*	D. M. + 38°. 1038,	V.	1	52	4·11	+ 38	53·4	0·09	9·5	Espin, No. 150; 1889, Nov. 26, 8·7. Wrongly identified in Cat. with D. M. + 38°·1010.
141*a*	D. M. – 0°. 986, .		27	0	3·07	– 0	3·8	0·05	7·5	Espin, No. 8; 1878, red. 1885, Feb. 27, 8½; fine red orange. Chambers; decided red. Vogel (Spect. Beob.); 1880, Jan. 18, whitish yellow; II.
143*a*	D. M. – 1°. 950, .		28	30	3·04	– 1	32·7	0·05	7·2	Espin, No. 9; 1877, Jan. 7·0; red. 1885, Feb. 27, 7½; red orange: March 7, 7·0; fine orange. Chambers; fiery red. Vogel (Spect. Beob.); 1880, Jan. 18, yellow; II*a* (?) III.
146*a*	. . . .		29	52	2·95	– 5	27·9	0·04	neb.	Earl of Rosse (Neb. Obs., p. 48); note on G. C., 1179. 1872, Feb. 3, 5th star of the trapezium, of an intense red colour: Dec. 31, very red.

No.	Star's Name.	Right Ascension (1890).			Precession in R. A.	Declination (1890).		Precession in Decl.	Mag.	Observations.
		h	m	s	s	°	′			
151*a*	D. M. – 1°. 1012,	V.	37	37	3·03	– 1	38·7	0·04	7·8	Earl of Rosse (Neb. Obs., p. 51); note on G. C., 1225; 8 mag.; very red. Espin; several obs.; orange, or pale orange red; II. (?)
152*a*	. . . .		39	5	3·86	+ 30	39·4	0·03	—	Chambers (M. N., XLVII., No. 6); No. 143; 7; good red. (Not in D. M.; an error of + 10° would make it = No. 153. Birm., 121.)
169*a*	. . . .	VI.	1	37	2·93	– 6	11·7	–0·00	neb.	Earl of Rosse (Neb. Obs., p. 52); note on G. C., 1359. 1850, Nov. 30, 28′ ± n. p.; a red 10 mag.
210*a*	B. 1429, . . .		54	51	1·22	– 54	54·0	0·08	7¾	A. G. C., crimson.
214*a*	A. G. C., 8938, .	VII.	0	22	0·90	– 59	17·9	0·09	7½	A. G. C., crimson.
215*a*	A. G. C., 8954, .		1	18	2·14	– 35	46·4	0·09	7½	A. G. C., crimson.
218*a*	. . . .		3	47	3·06	– 0	37·8	–0·09	neb.	Earl of Rosse (Neb. Obs., p. 56); note on G. C., 1500. 1877, Feb. 14, about 4′ s. p., is a reddish 10, with a white bluish 11 mag. 1′ s.
218*b*	D. M. + 14°. 1594,		6	4	3·41	+ 14	53·5	0·10	9·0	Espin, No. 351. 1889, Jan. 2, 8·3; very red; IV. type.
228*a*	V Geminorum, .		17	20	3·37	+ 13	18·2	0·10	var.	Baxendell (private letter); red. Knott (private letter); red.
228*b*	D. M. + 13°. 1655,		17	36	3·37	+ 13	10·8	0·10	8·4	Knott (private letter); red.
237*a*	. . . .	VII.	27	2	2·60	– 20	42·0	0·12	—	h. 3973; double 9·0; 10·0; pure white; remarkable brick red. Holden; No. 99; 1882·11; *comes* 9·5; a remarkable dull red.
243*a*	D. M. – 14°. 2082,		35	21	2·77	– 14	59·4	0·14	5·4	Konkoly; 1884, Feb. 20, gelblich roth; 6; II*a*!; splendid specimen, occasionally C. bright. (?)
247*a*	. . . .		37	0	2·68	– 17	54·5	0·15	—	Earl of Rosse (Neb. Obs., p. 61); note on G. C., 1567. 1874, Jan. 20, 9 mag.; red. 1877, March 3, 9–10; 12$^{\rm s}$·51 f.; 0″·8 n.
255*a*	D. M. + 22°. 1811,		49	53	3·55	+ 22	8·1	0·15	9·3	Knott (private letter); red, and var. (?)
259*a*	O. A., 7938, . .	VIII.	0	13	2·41	– 29	39·2	0·16	7¾	A. G. C., crimson.
259*b*	. . . .		4	50	1·36	– 56	19·6	0·17	8½	A. G. C., crimson.
264*a*	D. M. + 3°. 1958,		14	21	3·13	+ 3	6·6	0·19	8·3	Stone (M. N., XLIX., No. 5, p. 322). Bellamy; 8·5; vividly red. Espin; red; IV.
264*b*	Ll. 16381, . . .		15	19	2·60	– 23	6·9	0·19	7½	A. G. C., crimson.
285*a*	D. M. + 11°. 1954,		52	17	3·27	+ 11	15·5	0·23	8·5	Baxendell (private letter); red and var. Espin; 1888, April 14, 9·5; very red; IV. (?)
289*a*	Y. 3866, . . .	IX.	7	7	2·59	– 27	51·9	0·24	7¾	A. G. C., crimson.
291*a*	g Carinæ, . . .		13	6	1·70	– 57	4·9	0·25	4·8	Chambers (M. N., XLVII., No. 6); No. 274. Tupman; deep orange red.
305*a*	. . . .		57	37	3·24	+ 14	1·7	0·29	neb.	Earl of Rosse (Neb. Obs., p. 81); note on G. C., 2004; 8 mag.; red; 3$^{\rm s}$·96 f.; 94″·2 s.
308*a*	D. M. + 22°. 2200,	X.	11	54	3·32	+ 22	31·5	0·30	7·8	Earl of Rosse (Neb. Obs., p. 83); note on G. C., 2061. 1873, Dec. 27, 9 mag.; red.
308*b*	A. G. C., 14047, .		13	7	2·36	– 49	32·8	0·30	7¾	A. G. C., crimson.
308*c*	q Carinæ, . . .		13	25	2·00	– 60	47·0	0·30	3·3	Chambers (M. N., XLVII., No. 6); No. 301. Tupman; orange red.

No.	Star's Name.	Right Ascension (1890).			Precession in R. A.	Declination (1890).		Precession in Decl.	Mag.	Observations.
		h	m	s	s	°	′			
318*a*	A. G. C., 14642, .	X.	38	8	2·83	– 26	43·3	0·31	8	A. G. C., crimson.
318*b*	L. 4435, . . .		38	26	2·30	– 58	38·4	0·31	6·5	Chambers (M. N., XLVII., No. 6); No. 313; Brisbane; red.
320*a*	G. 1335, . . .		40	50	2·31	– 59	5·4	0·31	9	A. G. C., crimson.
320*b*	. . . .		41	46	2·32	– 58	59·2	0·31	10	Peek (Ast. Obs., p. 11); No. 862; double 8, 12; the larger star is very red. (A. G. C. makes them 9¾ and 10; can it be var.?—Espin).
320*c*	μ Velorum, . . .		42	2	2·56	– 48	50·5	0·32	2·9	Chambers (M. N., XLVII., No. 6); No. 316. Tupman; very red.
321*a*	u Carinæ, . . .		49	2	2·41	– 58	16·1	0·32	4·1	Chambers (M. N., XLVII., No. 6); No. 319. Tupman; bright orange red.
325*a*	x Carinæ, . . .	XI.	3	54	2·54	– 58	22·7	0·32	4·6	Chambers (M. N., XLVII., No. 6); No. 328. Tupman; deep orange red.
330*a*	D. M. + 22°. 2380,		30	40	3·14	+ 22	14·4	0·33	9·0	Earl of Rosse (Neb. Obs., p. 99); 1874, Feb. 9; 8·9; very red: April 14, 8·5; reddish.
330*b*	D. M. – 15°. 3323,		34	17	3·03	– 16	0·6	0·33	6·3	Chambers (M. N., XLVII., No. 6); No. 338; 6; red.
341*a*	ε Muscæ, . . .	XII.	11	39	3·22	– 67	20·9	0·33	4·7	Chambers (M. N., XLVII., No. 6); No. 349. Tupman; orange red.
347*a*	. . . .		18	48	3·20	– 48	48·0	0·33	—	Pickering (A. N., 2934); IV. type; var.
375*a*	D. M. + 38°. 2502,		55	59	2·82	+ 38	20·6	0·32	8·9	Espin, No. 372. 1889, March 28, 8·7; red; III. !!!; very deep bands.
388*a*	R Canum, . . .	XIII.	44	14	2·78	+ 40	5·3	0·30	var.	Espin, No. 275; var.; 7·2–13·5; orange red; III. !!!
410*a*	D. M. – 13°. 3944,	XIV.	34	31	3·27	– 13	35·0	0·26	7·0	Konkoly; 1884, May 24, gelblich roth; 7·5; II *a* (III. ?)
441*a*	D. M. + 48°. 2334,	XV.	47	30	1·79	+ 48	49·0	0·18	7·5	Espin, No. 380. 1889, March 22, 8·3; red; III. !!!; very deep bands.
446*a*	D. M. + 47°. 2291,		59	25	1·81	+ 47	35·7	0·17	6·6	Birmingham, 367. 1876, Aug. 20, very red orange; 7. Dunér; rouge-jaune foncé; III. !!! Bands of extraordinary size, and very black; spectrum totally discontinuous. Chambers; red.
482*a*	D. M. + 40°. 3110,	XVII.	6	44	1·95	+ 40	49·9	– 0·08	7·7	Espin, No. 381. 1889, March 22, 8·3; red; III. !!!; very deep bands.
516*a*	D. M. + 42°. 3007,	XVIII.	4	31	1·86	+ 42	12·4	+ 0·01	8·9	Espin, No. 384. 1889, March 22, 8·7; red; III. !!!; very deep bands.
522*a*	D. M. – 2°. 4578,		8	51	3·13	– 2	37·8	0·01	7·8	Espin, No. 405. 1889, Sept. 25, very orange red; 7·8; III. type.
528*a*	L. 7638, . . .		13	5	5·53	– 61	32·6	0·02	4·4	Holden, No. 156. 1883, 6 mag.; orange red.
532*a*	D. M. – 19°. 4992,		18	7	3·55	– 19	47·7	0·03	8·0	Holden, No. 160. 1883·58, yellowish red; 9 mag. (Arg., 7·8; 7; 8.)
535*a*	D. M. – 19°. 5015,		22	2	3·55	– 19	50·7	0·03	8·8	Holden, No. 162. 1883·57, yellowish red; 8·0 mag.
549*a*	D. M. – 7°. 4633,		31	7	3·25	– 7	41·4	0·04	9·0	Espin, No. 325. 1888, Sept. 7, 9·0; very red; IV. !!
554*a*	D. M. + 37°. 3180,		33	46	2·05	+ 37	41·0	0·05	7·0	Webb; 1882, Aug. 10, pale ruby; 9·0. E.'s obs. 1885, June 30, 6·5; pale red; var. (?)
589*a*	D. M. – 12°. 5299,	XIX.	4	42	3·35	– 12	19·1	0·09	7·5	Holden; 1882·61 mag.; 7·0.
595*a*	D. M. – 18°. 5389,		12	56	3·52	– 19	15·4	0·10	var.	Safarik (A. N., 2839); trübroth; var.

No.	Star's Name.	Right Ascension (1890).			Precession in Decl.	Declination (1890).		Precession in R. A.	Mag.	Observations.
		h	m	s	s	°	′			
621*a*	D. M. + 9°. 4264,	XIX.	42	43	2·86	+ 9	46·1	0·14	8·1	Webb; 1879, Sept. 3, 8·5, 9·5; 300° ± 50″; pale orange red; pale yellow. Es., 1885, Sept. 24, 25, pale orange and blue.
627*a*	. . . .		46	17	2·76	+ 14	43·5	0·15	—	Espin, No. 415. 1889, Sept. 22, 9·8; red; IV. type.
639*a*	D. M. + 20°. 4394,		57	59	2·63	+ 20	44·8	0·16	9·4	Espin, No. 416. 1889, Sept. 22, 9·3; very red; IV. type.
659*a*	. . . .	XX.	12	55	1·76	+ 49	36·0	0·18	—	Espin, No. 417. 1889, Aug. 20, 9·5; very red; IV. type.
662*a*	D. M. + 37°. 3876,		14	28	2·23	+ 37	6·9	0·18	9·5	Espin, No. 332. 1888, Sept. 12; 9·7; red; IV. type.
684*a*	. . . .		41	19	2·07	+ 44	27·7	0·22	—	Espin, No. 287. 1888, May 8, red; IV. (?) type; mag. 8·5.
703*a*	L. 8765, ...	XXI.	12	54	3·98	− 45	29·1	0·25	6·0	Pickering (A. N., 2934); IV. type.
706*a*	D. M. + 49°. 3535,		25	27	2·08	+ 49	50·7	0·26	9·4	Espin, No. 426. 1889, Aug. 29, 9·2; pale red; IV. type. (?)
710*a*	D. M. + 53°. 2684,		37	6	2·00	+ 53	49·4	0·27	8·6	Espin; 1890, Jan 27, 28, fine red; 8·0; III. ! ! !; magnificent spectrum; var. (?)
723*a*	D. M. + 52°. 3390,	XXIII.	7	18	2·68	+ 52	13·4	0·33	8·2	Espin, No. 335. 1888, Dec. 26; 8·8; red; III. ! ! !; very deep bands.

ERRATA.

Page 11. In Table, *for* June, *read* Jaune.
,, 13. In Table, *for* 615, *read* 666.
,, 15. *For* Knot, *read* Knott.
,, 18. *Add* A. Z. = Argentine Zone Obs.
,, 20. Nos. 7 and 20, *for* Casiopeiæ, *read* Cassiopeiæ.
,, 30. No. 110, *see* Addenda for correct place.
,, 41. No. 204, *add Schj.'s notes.*
,, 44. In column 3, *add* 107.
,, 47. No. 271, *for* rothlich, *read* röthlich.
,, 48. No. 295, *add*, in column 3, 120*a*.
,, 53. No. 350, *for* Bessell, *read* Bessel.
,, 55. No. 354, *for* rothlich, *read* röthlich.
,, 57. *For* Weisse, *read* Weiss.
,, 70. No. 526, *for* – 18° 17′·8, *read* – 18° 31′·2.
,, 95. No. 764, *for* 80, ORR., *read* 8·0, ORR.
,, 101. *For* Havard, *read* Harvard.
,, 111. No. 40, the obs. belong to Es.
,, 142. Footnote belongs to No. 382.
,, 150. No. 549, *for* Weisse, *read* Weiss.
,, 151. No. 553, *for* spectrum, *read* spectra.

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No. VI.

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BY

William

W. KITCHEN PARKER, F.R.S.

With Nine Plates.

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Professor William Kitchen Parker died suddenly of syncope of the heart on the 3rd of July, 1890, at Cardiff, while this Memoir was passing through the press.

Should any inaccuracies appear in the text, or in the lettering of the Plates, they are to be accounted for by the fact that my Father only received first proofs up to p. 41 before his death. At Dr. E. Perceval Wright's (Secretary of the Royal Irish Academy) request, I undertook the correcting of the remaining proofs; but, as I had not the opportunity of going through the Paper with my Father first, and as the proofs, both of the letterpress and of Plates V.–IX., had to be corrected as they came, it was not easy for me to revise the whole Paper as satisfactorily as I could have wished.

W. N. PARKER.

Cardiff, *November 14th*, 1890.

"CUNNINGHAM MEMOIRS."

No. VI.

On the Morphology of the Duck Tribe (**Anatidæ**) *and the Auk Tribe* (**Alcidæ**).

By W. KITCHEN PARKER, F.R.S. (PLATES I.–IX.)

[READ, FEBRUARY 10, 1890.]

INTRODUCTORY REMARKS.

THE materials for the present Paper have partly been in hand for many years, whilst the rest have been obtained during the last year or two. The *Shoulder-girdle* and *Sternum* of the Guillemot (*Uria troile*) were described in two stages in my work on those parts of the skeleton (pp. 146–148, Plate XVII.); and now the rest of its skeletal structure is given in this Paper. For the young of the Least Auk (*Ciceronia pusilla*) from Behring's Sea, I am indebted to Frederic A. Lucas, Esq., Washington; for the embryos and adult of the Razor Bill, and the adult Puffin, I am indebted to my son, Professor W. N. Parker; for the embryo of the Black-necked Swan, to Dr. Murie; and for the cygnets of the White Swan, to the late T. W. Pocock, Esq. The early stages of the Common Duck were obtained by me during the spring of 1887; and in these the dates of incubation were obtained.

For many years after the publication of my first two Papers on the Osteology of Birds,* my attention was directed solely to the skull, that part of the structure of the Vertebrata, the elucidation of which seemed to be my proper task. Of late, however, I have strayed into a "by-path meadow;" for the other parts of the organs of support promised me as much pleasure and profit as the skull itself.* That promise has been fulfilled; not one word of it has failed; and now I can only wonder at my own self-denial in not drinking from these other springs for so many years. That distinguished friend who first laid the yoke of the skull upon my shoulders, also tempted me into this wider field of research. In Professor Huxley's Paper "On Dinosauria and Birds,"† we have the following remarks:—"If the whole hind-quarters, from the ilium to the toes, of a half-hatched chicken could be suddenly enlarged, ossified, and fossilized as they are, they would furnish us with the last step of the transition between birds and reptiles; for there would be nothing in their characters to prevent us from referring them to the Dinosauria."‡

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* "On *Balænicepa rex*": Transactions, Zoological Society, vol. iv., Plates LXIV.–LXVII., pp. 269–351: and "On the Gallinaceous Birds and Tinamous": *ibid.*, vol. v., Plates XXXIV.–XLII., pp. 149–241.

The value of these remarks is not in the least diminished by any afterthought of the reader; yet it is true that they refer to the "hind-quarters" merely. But in its *neck* the bird resembles a Plesiosaurus; and in its *head* an Ichthyosaurus: moreover, there are various "remnants" in the *fore-quarters* of a bird that, as it seems to me, can only be interpreted by the light of the "paddle" of those aquatic reptiles. Hence I do not in the least believe that an Iguanodon begat the fore-fathers of the humming-bird.

The two families of birds whose morphology is treated of in the present Paper are very distantly related. The Alcidæ lie in the centre, so to speak, of a considerable number of families of water birds, and are manifestly related to the Grebes and Loons, Podicipedidæ, and Colymbidæ, birds that seem to be, both sorts of them, the modified descendants of Marsh's Hesperornis. However this may be, the Alcidæ are quite as nearly akin on one side to the Penguins as they are on the other to the Loons and Grebes; and there is this initial difficulty with regard to their relationship to ***any actual descendants*** of Hesperornis, that in that huge toothed bird the pre-sacral vertebræ are all "cylindroidal" in their articulation; whereas the Alcidæ, like the Penguins and the Gulls, have their dorsals "opisthocœlous." In this they are just a step above Marsh's Ichthyornis, which has its pre-sacral in a very low stage, namely, "amphicœlous," a condition that is not quite lost in the existing Laridæ. To complicate the subject still more, as if to keep the way of the *tree of descent*, Professor Huxley has already classified the Alcidæ and the Laridæ together. They are put with the Petrels (Procellariidæ), birds whose dorsals are cylindroidal, like those of Hesperornis, the Grebes, and the Loons.* But the true position and genealogy of the duck tribe (Anatidæ) presents as tough a problem as the auk tribe (Alcidæ); we have, here, a faggot of tough problems, that will task the ingenuity and strength of two or three generations of biologists.

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* See "On the Wings of the Common Fowl": Philosophical Transactions, 1888, Plates LXII.–LXV., pp. 385–398.

† Quarterly Journal Geological Society, 1869, pp. 12–31.

‡ *Loc. cit.*, pp. 30–31.

The structure of the skull in the duck-tribe is so similar to that of the fowls, in all things at first, and in many things permanently, that I have only taken up that part of the skeleton after it has acquired all the true anatine characteristics, namely, in the nearly ripe embryo of *Cygnus nigricollis.* For I had long ago worked out the skull of the common fowl, the early stages of which illustrate so accurately those of a duck, goose, or swan.† The skull of the guillemot (*Uria troile*), my example of an alcine skull, is worked out as early as the third stage in the chicken (*op. cit.*, Plate LXXXII.) The swan's early stage corresponds with one between the fourth and fifth stages in the chick (*op. cit.*, Plates LXXXIII., LXXXIV.). In the rest of the skeleton the more primitive condition of the parts has been worked out in the embryo duck. In these parts I have gone down far below the morphology of the adult Iguanodon, and have, as I believe, unconsciously thrown some light upon its development, for that huge beast was highly specialized. It had got a long way from its amphibian ancestors: its size, as well as its peculiar "hind-quarters," attest this.

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* See his Classification of Birds, Proceedings, Zoological Society, 1867, pp. 457, 458.

† See Fowl's Skull, Philosophical Transactions, 1869, Plates LXXXI.-LXXXVII., pp. 755-807.

THE MORPHOLOGY OF THE ANATIDÆ.*

The Cranium in Cygnus.

The intense ossification seen in birds makes this part of the skeleton a "closed book" in the adult; embryos, near the time of hatching, are the most profitable for interpretation of the various parts, and for comparison with what is found in the skull of other types.

The two extremes of cranial structure in those hot-blooded Sauropsida are to be found, on one hand, in the Tinamou, which retains many of its sutures, and has one, or even two, rows of supra-orbital scale bones; and, on the other, in a Passerine bird, where the metamorphosis of a skull, essentially reptilian, has reached its utmost perfection.

The *ectocranium* of the nearly ripe embryo of *Cygnus nigricollis* (Plate III., figs. 1–6, and Plate IV.) has most of its sutures open, and remains of those that are closing. These bones are very massive for a bird, and have a struthious coarseness about them: in the adult bird this is greatly altered by the absorption of much of the diplöe, for the sake of pneumaticity. The facial splints, as compared with those of the chick, are very broad; for we have in these "lamellirostres" (or sifters) a spoon-shaped bill, not ending insensibly in a more or less hooked point, but in a neat "unguis" like a finger-nail, and adapted to the flatter part in the mandible, like a thumb to a finger-nail in us. The premaxillaries (*px.*), as in osseous fishes, dominate the upper face: they form three-fourths of the spoon-shaped "rostrum," and are already ankylosed in the foremost third. Unlike mammals, the bird has long "nasal processes" to its premaxillarium—long, narrow splints, that run backwards between the nasals, and overlap the forehead. Laterally (Plate IV., *p. n.*) the dentary margin, covered with a false dentition of horny laminæ, overlaps the maxillary (*mx.*), and reaches to the jugal bar (*j.*, *q. j.*). The notch between these processes is rounded, and a similar notch in the nasal (*n.*) finishes behind a large oval space, in which is seen the alinasal folds (*al. n.*) and external nostril (*e. n.*). Already we have come across two agreements between the anatine and the gallinaceous skull, the hidden position of the maxillary like its counterpart, the "os mystaceum" of the perch, and the large oval space in which the nasal vestibule is exposed; these birds are both "holorhinal." The Alcidæ, as we shall see, are "schizorhinal," the nasals not being notched behind, but split.

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* See, on this subject, Dr. R. O. Cunningham's Paper "On the Steamer Duck (*Micropterus cinereus*)": Transactions, Zoological Society, vol. vii., Plates LVIII.–LXII., pp. 493–501.

In the Anatidæ the fore-part of the skull is very peculiar; the lachrymal or pre-orbital region is unusually long (see Plate III.). The nasals (*n.*) have a very large frontal plate, and the "hinge" is in front of that plate, not at the posterior edge of the nasal bones. They become thinned down and elastic where the motion is required. The lachrymals (*l.*) here attain their greatest size, and have the longest suture above; they then become narrow and are hooked backwards below, and help, by their hind margin, to enclose the very open orbit.

In the fore palate the premaxillaries (see Plate III., fig. 1, *px.*) have a short palatine process that binds upon the inner edge of the maxillaries (*mx.*); the median region is taken up by the huge temporary prenasal part of the intertrabecula (*pn.*); half the dentary edge is formed by the maxillary, overlapped by the premaxillary; each palatine process (or maxillo-palatine, *mx. p.*) runs inwards and backwards, approximating, behind, to its fellow; and then, ending in a rough point, they diverge to embrace the vomer at its thickest part. This latter bone is a flat vertical spatulate plate, with its broad end behind; pointed somewhat there, it is again fixed between the sharp styloid "ascending processes" of the palatine (Plate III., figs. 1 and 5, *v.*, *pa.*). At present the vomer is only composed of one centre; another appears on the antero-superior corner afterwards (Plate II., fig. 15, *v.*). The vomer, palatines, and pterygoids belong to the mid-palate; a pre-palatine bar, however, runs far forwards, wedged into a deep notch in the maxillaries. These large, long bones (*pa.*) form the lateral boundaries of the nasal passages, which open at their hinder part in one common median "posterior nostril." Their widest part is near the angle of the upper jaw; they narrow in, sinuously, to their end; they approximate then, and send forwards and upwards their sharp ascending process. The "middle nasal openings" are between the vomer and the palatines.

The next bones are the pterygoids (*pg.*). They are only one-third the length of the palatines, which are wedged into their fore-part below; whilst the pterygoids form a peg in front, which is fitted into the upper face of each palatine. This is a curious doubly-pegged joint, which is imperfectly developed in the fowl tribe; *their* palatines and vomer are very slender, and the pterygoid peg is not so small and neat; it is styloid. Nevertheless these two families agree in having a truly azygous vomer, and in not having this pterygoid peg segmented off and fused with the palatine, as in most birds. Also in the small epipterygoid process of the pterygoid, in the breadth of its fore end, and in the fact that it articulates with the basipterygoid processes of the basis cranii at its front third, the geese and fowls agree. For, in most birds, when these parts are developed, the articulation is at the middle of the pterygoid: in the struthious birds, Tinamous, and in the embryo of Opisthocomus, it is at the end.

Although the palatines and pterygoids, because of their histological development, are here classed with the parts of the "ectocranium," they are in reality degenerated *endo*-cranial tracts that have lost their cartilaginous pith.

Behind the palate, under the broad hind-part of the endocranium, there are three tracts of parosteal bone that at an early stage became fused together as one tract this bony growth is the "parasphenoid"; the three parts are the "basi-temporals" behind, and the "rostrum" in front (Plate III., figures 1 and 5, *pa.s.*, *s.*, *r.b.s.*, *b.t.*).* Of all birds the fowls and the duck tribe have the basi-temporals most massive; this is well seen in the goose, and in *Tetrao urogallus.* The parasphenoid is generally, not always, in one piece in the Ichthyopsida; it sometimes has a separate centre in front in certain frogs.† It grafts itself on the basis cranii, aborting the cartilage, in some of the Urodela.‡ In birds which have a certain amphibian stigma§ in many parts of their organization, this grafting of a "parostosis" on the basal cartilage, thus taking the place of a normal endoskeletal bony centre, takes place very early; and the three primary centres, fused into one, support, in front, the interorbital wall, then develop large "anterior tympanic recesses," and, behind, form most of the thick but excavated basicranial floor (see Plate III., figs. 1 and 5, *r.b.s.*, *b.t.*, *a.t.r.*, and Plate IV.). The basi-temporal mass, a transverse tract bulging forwards at the middle, lies on a lower plane than the fore-part; in a deep chink between the two masses, the eustachian tubes (*eu.*) converge towards each other.

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* Fowl's Skull, Plate LXXXII., fig. 2.

† Philosophical Transactions (1881), Plates V. and VIII.

‡ Transactions, Linnean Society, series ii. (Zoology), vol. ii., Plates XVII. and XX.

§ In the existing reptiles the parasphenoid is but little developed.

I have already spoken of the articulation of the basi-pterygoids with the pterygoids; this takes place in a remarkable manner,* for a new plate of cartilage is developed on both bones; in the Struthionidæ† the pterygoids acquire an articular plate of cartilage, but the basi-pterygoids are direct outgrowths of the basis cranii, and their articular facet is formed by an arrest in the process of ossification of the outgrowth, as in Lizards.

This shows how far the fowls and the goose tribe have travelled from those archaic birds—the Struthionidæ and their immediate allies.

The cheek, in this and most birds, is very feeble, and is formed of three overlapping splints, the foremost of which is a mere outgrowth of the maxillary, its jugal process. This is overlapped by a separate style of the same size, the jugal (*j.*); and under and within these the quadrato-jugal (*q.j.*) binds the whole together to the quadratum (*q.*); it is one-third longer than the jugal, and is hooked inwards behind, where it is articulated to the quadrate. These parts are true parostoses, and are extremely unlike their broad counterparts in the Crocodiles and Tortoises, and in Hatteria.

The roof-bones and temporal plates add three pairs more to the category of parostoses; the foremost of these are the frontals (*f.*), which are the largest bones in the skull, and are yet extremely deficient above and over the orbits. A large "fontanelle" still exists at the part where the small hole is seen in Lizards—the *orbit* of their median eye; in old geese this fontanelle remains, sometimes bringing the bird near the Lizard, but

* See Fowl's Skull, *loc. cit.*, Plate LXXXIII.

† Philosophical Transactions, 1866, Plates VII.–XV.

the organ itself is very little developed in birds. The parietals (*p.*) are of small axial extent in the Anatidæ, as in the Ruminant and Cetacean Mammalia; they meet the frontals, are overlapped laterally by the squamosals (*sq.*), and overlap the supraoccipital (*s. o.*).

The squamosals (*sq.*) are roughly pentagonal bones that overlap the frontals and parietals at their junction, binding the supraoccipital (*s. o.*) behind, and forming an eave over the auditory recess.

The rest of the osseous centres belong to the *endocranium.* These are transforming the massive "chondrocranium," a remarkable beaked structure, with a short, wide, cranial basin. This has to be described before the bony tracts.

Much of this can be seen from below (Plate III., fig. 1), and has also to be surveyed on its side (Plate IV.); its end (Plate III., fig. 3) from above (Plate III., fig. 2), and in a section taken longitudinally and vertically, a little to the left of the mid-line (Plate III., fig. 5); thus the crested and rostrate fore-part is seen from its side, and not in section. The occipital base, sides, and plane show that this part is a bulging and oblique hindwall; it also forms the hindmost part of the floor. The auditory capsules (*au.*) are very large, and are jammed in obliquely between the occipital arch and the sub-transverse posterior sphenoids.

At present the notochord (*nc*) forms the axis of the basi-occipital bone (*b.o.*); it has shrunk from its extension into the posterior clinoid wall (Plate III., fig. 5, *py.*), and now forms only the axis of the hindmost cranial segment. Right and left, it was enclosed in the "parachordal" cartilages, which becoming alate laterally, and their wings meeting over the myelon, formed also the hinder skull basin and its end wall, *i.e.* alisphenoids (*a.l.s.*), exoccipitals (*e. o.*) and supraoccipital (*s. o.*).

The proper axial skeleton, namely that related to and formed upon and around the notochord, ended from the first behind the pituitary involution of the oral membrane. The chondrocranium therefore is sharply divided into a *post-pituitary* and a *pre-pituitary* region. Looking at these parts from the standpoint of adaptation the pre-pituitary part seems to be a morphological aftergrowth—almost like an afterthought. For in these *high* skulls, as in the high skulls of many osseous fishes the fore-part of the skull serves mainly as an orbito-nasal wall, a partition run up between the eyeballs behind and the nasal capsules in front; in the bird, as in Cartilaginous Fishes, that which forms the middle part of the foundation of the wall is carried forward as a long "pre-nasal rostrum." This part forms most of the skeleton of the skate's large beak; in the bird it is *the temporary model on which the secondary facial skeleton is formed.* But the skate has a *low* and the bird a *high* skull; in the one the brain lies down on a flat floor; in the other it is tilted up behind and a little over the interorbital wall (Plate III., fig. 5).

In this, as in other things, the bird is not the direct offspring of any form that we know of: it has chosen this and rejected that, "wittingly," so to speak; its feathers are a "new thing upon the earth." The space between a lizard's scale and a peacock's train-feather is very considerable, and I know of no hot-house and no manure that would "force" the one to form the other. As far as to the hinder part of the *septum nasi* (*s. n.*) the pre-pituitary part of the chondrocranium is formed of three rods: the trabeculæ and intertrabecula (*tr.*, *i. tr.*).* These parts are, as far as my researches show, the oldest by far; the cartilages that form right and left of the notochord appear to me to be comparatively recent developments of the cartilaginous supporting tracts.† Over the optic nerve (II.), morphologically between it and the olfactory nerve (I.), the trabecular or pre-pituitary wall shows a slight development of the orbito-sphenoids (*o.s.*). Between the olfactory regions the nasal roofs are continuous with the common orbito-nasal partition-wall; and the median part sends backwards a small *crista galli* (*cr.g.*). The roof is in three regions, namely, the "aliethmoid" (*al.e.*) behind, the "ali-septal" (*al.sp.*) in the middle, and the "ali-nasal" (*al.n.*) in front; the latter folds not covered with bone (Plate IV., and Plate III., fig. 2, *al.n.*). The true olfactory region is short and simple, and is walled in behind by a fold which corresponds to the "pars plana" of human anatomy; but there are no special "upper" and "middle turbinals" in this and other Carinate birds. The inferior turbinals

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* See Challenger Reports, "Skull of Green Turtle": Zoology, vol. i., Plate II., figs. 6, 7.

† See my Paper "On the Marsipobranch Fishes": Phil. Trans., 1883, Plates VIII.-XXVI., pp. 373-453.

are scrolls of cartilage with from one and a-half to two coils;* they remain unossified as a rule.† In the generalized, archaic, and retrograded Struthionidæ the turbinals anticipate those of Mammals, and are extremely complex.‡ Also in these birds§ the solid orbito-nasal partition is never taken away in any part; in the Carinatæ it is removed, under the naso-frontal transverse line, to form the *cranio-facial hinge*, a remarkable structure peculiar to Carinate birds, and necessitated by the abortive development and new function of the fore-limbs. This departure from what is typical is well shown in the swan's embryo (Plate III., fig. 5, *c.f.c.*); for the "cranio-facial cleft" is now a large round notch and is quite similar to what is seen in some species of those of undecided types—those Struthious Carinatæ, the Tinamous.|| The trabeculæ in their fore-part, and the intertrabecula at its hinder third have been roughly sawn across, so to speak, and the wall, above, removed for three-fourths of its height. Here we have a secondary segmentation of parts that in us are only marked off by the different condition of the tissues, the "perpendicular ethmoid" being ossified, and the "septum nasi" only partially calcified. Here the perpendicular ethmoid (*p.e.*) is already larger than the membranous space that separates it from the septum nasi (*s.n.*).

The morphology of the "pre-nasal rostrum" (*pn.*) is evident: it is a mere fore-growth of the intertrabecula, and in skates, saw-fish, and even in some Ganoids it is often of great length.¶ If we look at the under view (Plate III., fig. 1) and at a much earlier stage in the chick (*op. cit.* Plate LXXXII., figs. 2 and 2A, *p.n.*) we shall see what use is made of it in the bird, where it is first used, and then absorbed. It is more spatulate in the swan's than in the fowl's embryo, being the model in the former case of the large premaxillary spoon.

The brain is tilted up over the orbito-sphenoidal region, and lies low down

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* Fowl's Skull, Plates LXXXIII. and LXXXVI.

† In Land and Water birds.

‡ Ostrich's Skull, Plates X. and XII.

§ *Ibid.*, Plates VII. and VIII.

|| Ostrich's Skull, Plate XV., fig. 8 (*c.f.c.*).

¶ See "On *Lepidosteus osseus*": Phil. Trans., 1882, Plate XXXVIII., fig. 1 (*p.n.*).

in the broad hollow of the cupped hind cranium, the post-pituitary or notochordal region. Here the *chondrocranium* is rapidly ossifying even in this water bird with *precocious* young. But in those birds that have tender young, the "Altrices," in which the Carinatæ have many culminations, the process is much more rapid, as are all these *pre-nasal transformations*. In the wren (*Troglodytes europæus*) at the twelfth day, when it is ripe for hatching, it has had only half the time for development as this almost ripe embryo of the swan, and yet it is as far advanced. Here in the case of the wren we see the result of a veritable "forcing" process in a real, and not imaginary, "hotbed." The parachordal cartilages have formed a transversely kidney-shaped occipital condyle (Plate III., fig. 1, *oc.c.*), and the basioccipital bone (*b.o.*) is oblong; it has not proceeded far right and left of the notochord (*nc.*). The ex-occipitals (*e.o.*) are multiangular plates, that are margining the foramen magnum, and enclosing the outgoing hypoglossal, vagus, and glosso-pharyngeal nerves (xii.). There is still a large cartilaginous bed in which these bones lie; at a distance above them, equal to their breadth, we see the large double supraoccipital (*s.o.*). This bone has the remains of its primary suture above; it is shield-shaped, with the sides deeply notched; this round notch half encloses the "lateral occipital fontanelle" (*l.o.f.*), which is finished by the squamosal and auditory capsule. This structure is confined to the Grallæ, plovers and cranes, &c., and to certain water birds—gulls (in which it becomes filled in afterwards), and Alcidæ, besides these normal Chenomorphs. Here the goose tribe parts company with the fowls, which have no such structure. The frail skull of the lesser Limicolæ shows a notch above the foramen magnum, where the two supraoccipital centres have not united. This notch tends to fill in in the hemipods, but in pigeons and in owls it does not fill in, except below, so that a "middle occipital fontanelle" remains, a mere pin-hole *like the parietal orbit of Lizards*, but assuredly without any such meaning as that famous "sky-light"; so the mind of the morphologist is greatly exercised as to the purpose of these closed-up windows.

Laterally, the posterior sphenoid has the main part of its wings ossified as the alisphenoids (Plate III., fig. 5, *a.l.s.*); these are almost transverse in this position, and form, indeed, the post-orbital wall. Not only so, they send out a large spur of cartilage (Plate IV., *sp. o.*), the "sphenotic process," which, in some birds (*e.g.* owls), is ossified separately, and thus gives us the remains of the large *post-frontal* bone (sphenotic) of an osseous fish. In the old bird this might be taken for a post-orbital process of the frontal, or for a rudimentary zygomatic process of the squamosal; it is overlapped by those parts, but belongs to the endoskeleton. I find no other Vertebrates except the Urodelous amphibians that anticipate the peculiar development of the basi-sphenoid of the bird. The basal bars that unite to form the main beam in a reptile are ossified intrinsically. The bird, like the Urodela, has no distinct "basisphenoid"; but the cartilage borrows its bony matter from the hind part of the median parasphenoid, after which it runs forwards, free from the cartilage, as the "basisphenoidal rostrum" (Plate III., fig. 5, *pa.*). Once the ossification overtakes the cartilage round the pituitary space (*py*), it runs rapidly into the floor of the skull behind, and right and left. Together, this grafted bone, and the superficial growths—which form the anterior tympanic recesses, and the basi-temporal plate—produce in the bird, whose skull is so thoroughly pneumatic, very complex tympanic outworks, as complex as those of the crocodile,* but of a different type.

As in those osseous fishes that have a high skull, the pituitary floor is open; it is finished by the parasphenoid; the internal carotids (*i. c.*) enter the skull through this space, creeping over the basitemporal plate, whose diplöe forms a bony tube for each artery. At present the pinched-up anterior sphenoid (*o. s.*, *p. s.*) is unossified; but the perpendicular ethmoid (*p. e.*) is a large slab of bone behind the notch for the hinge, larger than the notch. The *auditory* sense-capsules, like the *olfactory*, are built into the cranium, and have to be described as parts of it, although they have no original right to this position. These parts are very large, and each cartilaginous capsule, which is planted like a bulb in the side wall of the hind skull, soon coalesces with the proper cranial walls. These oval capsules are tilted backwards, so as to lie supine, and almost in a horizontal position (Plate III., fig. 5). The upper part of each capsule is occupied with the three *semicircular canals* (*a. s. c.*, *p. s. c.*, *h. s. c.*), and under the arch of the anterior canal there is a recess like that for the "flocculus cerebelli" in the Mammal. The *lagena*, or rudimentary cochlea, is buried in the basilateral cartilage (Plate III., fig. 1) over the hind edge of the basitemporal plate. The recess, or "meatus internus" for the seventh and eighth nerves (vii., viii.) is shallow, the meatus externus is membranous and very short, and the tympanic cavity is formed by the utilization of many parts round the primary tympanic (or 1st) *cleft* (see Plate IV.). In front, the large quadrate bone (q), mistaken by our ancestors for the *tympanic, and mistaken for it still by those who are not embryologists*, forms the front wall of the porch. Its floor is formed by the basitemporal, its inner wall by the auditory capsule, and its roof and sides by the squamosal. Sometimes there is one, sometimes more than one, *six* even, true *tympanic* bones.* I find no separate tympanic in the Anatidæ; but in the duck the floor and sides approximate, closing in the cavity, all but a narrow chink; this structure is seen still better in the green woodpecker (*Gecinus viridis*).† In that bird this secondary tympanum is like a small Cowrie shell (*Trivia*). Round the meatus internus (Plate III., fig. 5, vii., viii.) a considerable oblong bone, the periotic (*pro.*), is already formed; the opisthotic (*op.*) is seen behind and below; a chink separating it from the exoccipital (*e. o.*); it is a much smaller bone; externally it joins the delicate bar that separates the *fenestra ovalis* from the *f. rotunda.* The epiotic is not seen here, and is rare in birds.

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* Transactions, Zoological Society, vol. ii., Plates LXII.–LXXI.

There are three *visceral arches* developed in a bird; the palatine extension forwards—a part of doubtful morphology—I have already described as the *pterygoid* and *palatine* membrane bones: bones that had no true cartilaginous model. The proper pier of the mandibular arch, the quadrate (q), is well developed; it is much more like that of an amphibian than the quadrate of a serpent or a lizard. It is indeed developed distinctly from the chondrocranium, and does not coalesce with it at any part; but it has a large "pedicle," or orbital process, and a large "otic process" with two condyles, as in the Peristeropodous Gallinaceous birds, and in most of the Carinatæ. The quadrate has already a large bony shaft; the pedicle and the articular regions are still soft. That bone corresponds to the upper piece of a branchial arch, with only two segments; that is its true nature: it is a "pharyngo-epihyal." The core of the mandible is a cerato-hypohyal (Plate IV. and Plate III., fig. 4, *ar. mk.*). Here let it be noticed that the *posterior* and *internal* angular *processes* (*p. a. p.*, *i. a. p.*) are parts of this "articulo-meckelian" bar; these processes are unusually developed in the cultrirostral fowl, and in these lamellirostres, also in that lamellirostral relation of the Ibis, the Flamingo. The cartilaginous rod (*mk.*) runs inside the dentary splint (*d.*) nearly to its end; and the kinship of the trabeculæ to the visceral arches is nowhere more plainly suggested than in this stage of the bird; that, however, is a knotty problem. There are *two layers* of bone covering this rod, a *deep* and a *superficial* layer. The deep deposit is the *ectosteal* "articulare"; its *endosteal* part has not yet appeared; the superficial or parosteal bones are the dentary (*d.*), the splenial (*sp.*); the supra-angulare (*s. ag.*) and the angulare (*ag.*). I find no coronoid in this family, nor in the Gallinaceæ; otherwise it is quite like the mandible of a reptile; the coronoid does turn up in the Passeres, and in some Grallæ.

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* Transactions, Zoological Society, vol. ix., Plates LV., in *Corvus corone.*

† See Transactions, Linnean Society, second series (Zoology), vol. i., Plate II., fig. 2.

The *hyoid* arch of this, as of other birds, is essentially reptilian. Its "pharyngo-branchial" element is, at first, quite separate from the rudiments of the rest of the arch. All those Vertebrata that have a *fenestra ovalis* have the pharyngo-branchial element of the second visceral arch modified, as a *stapes* or *columella*. This may be severed from or united with the other segments of that, the hyoid arch. In the Hatteria, and for a time in the Crocodile, these parts become united: in the bird they also unite, and the arrested sub-apical or epi-hyal element remains continuous (confluent) with the stapes. It is generally very small, but sometimes shows a dilated cerato-hyal tract. In the crow,* in the fowl,† and in the Anatidæ, Alcidæ, and many others, it varies very little, and is extremely small and slender.

The distal part of the hyoid arch (Plate III., fig. 6), below the aborted membranous tract, is mainly hypo-hyal; but that is not a separate segment, and the term for this part is still "cerato-hyal" (*c. hy.*); the two, right and left, coalesce in front, and almost separate off a true basihyal. This *lingual skeleton* is very large in these Anatidæ. The third

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* Transactions, Linnean Society, series ii. (Zoology), vol. 1., Plate XX., figs. 8, 9.

† Fowl's Skull, Plate LXXXVII., fig. 3.

visceral arch, corresponding with the first branchial arch of an osseous fish, is composed of two segments (*br.*), nearly equal in length. The lower of these is almost ossified. The upper in these birds is thick below; and the thick part is flat above. This is very characteristic of the duck tribe. There is a basal piece of cartilage, thick in front of the articulation of the third visceral arch, and slender behind; the fore-part of this (*bh. br.*) corresponds with the first basi-branchial of an osseous fish; the hind-part with the second, and even third.

In a nestling cygnet of the common swan (*Cygnus olor*), fourteen inches long, and presumably three or four weeks old, the skull as seen in section (Plate V., fig. 1) shows a great advance in development as compared with the almost ripe embryo. The superficial bones are still distinct, but they meet well together now, and are acquiring their permanent form. The frontals (*f.*) are still very thin; but they and the short parietals (*p.*) have obliterated most of the great upper fontanelle of the embryo. A small triangular patch of the squamosal (*sq.*) can be seen inside the skull. In front the premaxillaries (*px.*) are fused together, except in their thin nasal processes; and their *core*, the prenasal cartilage, is now absorbed: they soon after this become fused with the maxillaries. The basi-sphenoidal rostrum (*pa.s.*) is still free from the base of the interorbital septum, except behind; and, further back, the basi-temporal plate (*b.t.*) shows its independence of the basis cranii proper. The perpendicular ethmoid (*p. e.*) forms the hind boundary of the *hinge notch* (*c. f. c.*). It has reached the top of the plate, where the aliethmoidal folds are given off; and behind it reaches the small interorbital fenestra (*i. o. f.*). Below, it only reaches to the trabecular beam, which projects a little in front of it, and is then lost for a space; this beam reappears under the irregular septum nasi (*s. n.*), but all the pre-rostral part in front has disappeared. Where the septum nasi leans forward above, giving off the ali-nasal folds, there an oval space is seen under it, finished below by the bones of the face. This is often seen in water-birds as an open window between the right and left nostrils. The alisphenoids (*al.s.*), the borrowed basi-sphenoid (*b. s.*), the basi-, ex-, and supra-occipitals (*b. o.*, *e. o.*, *s. o.*) are all well developed, and are only divided by a narrow tract of cartilage. The small opisthotic (*op.*) clings, now, close to the large prootic (*pro.*); the epiotic is replaced by a large ingrowth from the supraoccipital (*s. o.*). The passages for the outgoing nerves (i., ii., v., vii., viii., x., xii.) can be seen well in this view.

In a gosling (*Anser palustris, domesticus*) six weeks old I found the well-known antero-superior spine of the vomer in a separate condition (Plate II., fig. 15, v., vi.). In the adult black swan (*Cygnus atratus*, Plate II., fig. 14, *pa.*, *i. pa.*) I found a pair of inter-palatine bones that tend to make this bird doubly desmognathous. The same milioline bones are often found in the Ducks (Anatidæ).*

In the old *Cygnus olor*, as in *Chauna chavaria*, the forehead becomes largely swollen and pneumatic, and the lachrymals, fused with the frontals, are extremely large and swollen; the sphenotic process also being very large, these parts nearly meet below the orbit. In *Dendrocygna acuta* these processes do meet and coalesce; thus a suborbital bar is formed, like that which is seen in most of the Psittacidæ.

In the old white swan (*Cygnus olor*) the lateral occipital fontanelles become filled in with periosteal bone: in an old black swan (*Cygnus atratus*) I find them open but small.

The interorbital fenestra becomes filled in in the swans; and in the common species this part is very thick and spongy.

There are several kinds of birds that have a dentated horny mandible: none outside the Anatidæ have the "quaffering organ" perfect, except the Flamingo, a "Pelargomorph." But the archaic Chenomorphæ—the Palamedidæ—are cultrirostral, and have a beak similar to that of a fowl: they look downwards in the direction of the *Gallinaceous Root;* and the Peristeropodes of the same region, like them, become desmognathous. We should have to travel far back, however, before we came to the meeting-place of these two types. Within the bounds of the Anatidæ, proper, the bill varies extremely in width: the two extremes are the Merganser (*Mergus*), and the Shoveller (*Spatula clypeata*).†

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* See Wiedersheim's Comp. Anat. of Vertebrates: Translation by W. N. Parker. Macmillan & Co., 1886: p. 79, fig. 65, *B. pl.*

† See Shufeldt "On the North American Anseres": Proceedings, U. S. Nat. Mus., vol. 11, pp. 215–251, fig. 2, p. 218, and fig. 16, p. 232.

On the supposition that the cold- and hot-blooded Sauropsida—reptiles and birds—have arisen, during time, from a similar (or the same) amphibian platform, this one family (the Anatidæ) is sufficient to show what the morphological force can effect when working on teleological lines.

On the Development of the Vertebral Chain in the Anatidæ.[*]

In the present Paper I shall deal with that in which these birds differ from the Fowl tribe. The earlier stages have been worked out in the chick, and the results will be published, at an early date, elsewhere.

On the Vertebral Chain in Cygnus nigricollis *and* C. olor.

In the advanced embryo of *Cygnus nigricollis* (Plates III. and IV.) the vertebræ are in what may be called a Reptilian stage; the osseous centres are still distinct. The swans, however, although they are the true nobility of the tribes of the water-birds, are yet remarkable for the retention of some Reptilian characteristics. This is true as to the great length of the chain, and also because of the presence of ribs up to the occiput. This is also seen in the large Ratitæ; but even the largest existing form—Struthio—has not so many vertebræ, by ten, as the common swan. On the other side of the Class, the specialization of this chain by the suppression of possible links or segments is seen in the multitudinous lesser Passerines, and in swifts, humming-birds, and other Coccygomorphæ. More than half of the *twelve thousand* species known have, on an average, only *forty* vertebræ, even in the embryo. The African ostrich has *fifty-six*,[†] and the common swan *sixty-three*. Numerical law is not very strict in birds; yet those six thousand species just mentioned have in a great majority just *fourteen* cervicals, or twice as many as in Mammals. *Twelve* also is a common number for the *avian sacrum* in the small high-type birds; and from *ten* to *twelve* vertebræ in the caudal region is as a rule the number in the embryo. In this embryo there are *twenty-two* sacrals and *twelve* caudals: there are *five* dorsals in swans—a common number. But in the same bird, on the two sides, the number of lower cervicals that have free ribs, the number of dorsals, and the number in the secondary divisions of the sacrum—all these things are variable to a remarkable extent.

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[*] For an account of this part of the skeleton in birds generally, see Proceedings, Royal Society, 1888, pp. 465–482.

[†] See Mivart, Transactions, Zoological Society, vol. viii., p. 430.

As to the adaptive modifications of the several links of this beautiful chain, there is nothing like it in the class to which *we* belong. Birds "seal up the sum" of adaptive modification of these intercalary segments of the vertebrated organism.

In the cervical region *C. nigricollis* has one less than the common swan—only *twenty-four*. The first two of these (the "atlas" and "axis") are less perfectly ossified than most of those that follow; but in these the two moieties of the neural arch are ossifying, and in the axis, its *own centrum*, in the hinder part of the body. I shall explain this in the next stage. The third to the eighteenth inclusive have a bony tract in their rudimentary ribs. The last two, the twenty-third and twenty-fourth, have segmented styloid ribs that are fast becoming bony. Much, however, of each vertebra is cartilaginous; and the notochord (on which these rings are strung—through their *base*, not through their *canal*) is still of considerable size.

But the type of these vertebræ is already established. They are "cylindroidal" or "heterocœlous"; so are all the pre-sacrals. The cartilage, but not the bone, has met over the neural canal. The *riblets* that protect the vertebral arteries, half-filling in their long burrowing passage, were, for an extremely short period, distinct as cartilaginous points, as I shall show in another Paper. They now connect the "diapophyses" with the "parapophyses"—the upper and lower "transverse processes"; and all distinction of parts is lost up to the twenty-second vertebra. The styloid part of these costal "remnants" is lost in the nineteenth and the three next vertebræ; and in this stage the osseous centre has not yet appeared. These birds are remarkable in that the *axis* only has an upper and lower spine. In the third both are obsolete: the upper, even, is a mere ridge. This is remarkable; for of all birds the swan has the longest neck, and moves it with most variety and grace; moreover, in grazing and quaffering it uses considerable force. Nor is there any closed inferior arch for the carotids in these types, such as is seen in the heron and its congeners, long-necked birds, but in which the length is gained rather in the individual vertebra than in a great number. In the lower part of the neck the neural arch gradually becomes crested, thus approximating to the dorsal region: a feeble keel also appears below. The rather long cervicals increase in their width, gradually, until they reach the large wide dorsals: near them they shorten. The facet for the "tuberculum" of the free ribs gradually creeps upwards so as to fit under the end of the large transverse process: that for the "capitulum" is a raised oval basin near the fore margin of the projecting articular part of the *centrum*. In these things the dorsal vertebræ agree with the two last cervicals. The spine is now a large obliquely oblong up-growth, and the upper transverse processes are very wide: they all have a slight lower spine, which becomes feeble in the last, and is nearly obsolete in the first sacral (dorso-sacral).

Amongst the other Carinatæ there is no such *sacrum* as this of the swan; it is nearly twice as long as in the multitudes of small and high-class birds. Here, in this embryo, there are *twenty-two* vertebræ (Plate IV. and Plate III., figs. 9, 10) enclosed between the ilia, and indeed the next, or first caudal is partly between those plates.

Here ossification is confined to the basal region; the sheath of the notochord has acquired twenty-two bony rings; and the osseous matter has crept into the investing cartilage, right and left; in the true sacral region, where the vertebræ are very short and wide, the deposit is bilobate; there are not, however, two separate centres, for each centre begins round the azygous notochordal axis. The great *Avian sacrum* has four regions, namely, the dorso-sacral with four vertebræ, the lumbo-sacral with three; the sacral, proper, with four, and the uro-sacral with eleven.

The spines are never quite obsolete, but are highest at the two ends of the series; the fourth dorso-sacral has half-developed ribs, to which belong half-grown sternal pieces below (Plate IV.). The three lumbo-sacrals have only thick, short diapophyses, buttressing the *pre-ilia;* the next four, or sacrals, proper, have these abortively developed in their lower part. Prickles are seen in the last two, however, and these are remnants of ribs. This is seen in the two next or first two uro-sacrals, where they are separate bars, and become separately ossified like their several homologues in the neck. The rest of the uro-sacrals have only diapophyses; all these in the true sacrals and uro-sacrals, are pedate or dilated where they articulate with the *ilia*, and being broad, proximally, they thus leave a round space, which is filled with the corresponding ganglion of the "posterior root" of the sacral nerve (*g.*). Both in the lumbo-sacral, sacral, and uro-sacral regions there is, in an earlier stage than this, an abortive attempt at forming more ribs than remain, even as remnants, for in the embryo of the common duck I find the first five uro-sacrals with rib-bars; the last three of these, however, are soon lost.* In these vertebrates the *metamorphosis* of the organism is not confined to a certain strict term, as in insects, but goes on for a long and, indeed, indefinite time; the "Anura" show this to a lesser extent. The diminishing series of vertebræ that form the skeleton of the tail (*cd. v.*) has its transverse processes longest in the middle; its spines are low and broad, and the third has, beneath, a small intercentrum which passes under the second: there are seven of these milioline cartilages. In this specimen there are *six* free simple vertebræ, and in the uropygial part six more; the last of these segments, however, is merely the naked end of the notochord (*nc.*) sticking out; it does, however, become clothed with cartilage, and then converted into bone. At first the uropygial piece (*region*) is formed, as a rule, of *six* segments; long ago, however, in the winter of 1842–3 I found in a recently-hatched common duckling ten osseous centres in a row in this part (Plate II., fig. 12). This was, most likely, due to domestication. Like the overgrowth of digits in the foot of the Dorking fowl, it is a proof of the exquisite sensitiveness to surroundings that exists in these types.

Of the distinct and functional ribs in this embryo seven had perfect sternal pieces; the eighth pair were nearly perfect; their lower bars were not ossified; the rudimentary ninth piece was far from its arrested upper bar; the ribs were rapidly ossifying; the long last cervical, and four at least (generally in swans the fifth also) have appendages (*c. a.*), cartilaginous tracts growing from the middle of the rib, at its hind-edge, and overlapping the next following rib. The sacral and caudal regions of embryo ducks in earlier stages than this (Plate II., figs. 1–3) will be described with the hip girdle.

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* See Proceedings, Royal Society, 1888, p. 479.

In the *second stage* cygnets of *C. olor*, fourteen and fifteen inches long, and about a month old, there are many important changes to be noticed in the vertebral chain.

In the *atlas* (Plate V., figs. 2, 2A, 3, *at.*) the two centres of the neural arch are united above, and a considerable deposit of bone has taken place in the base; that basal piece, however, is not the true centrum, but an occipito-atlantal "inter-centrum" (*i.c.*). The centrum, proper, of the atlas has become fused with that of the axis (*ax.*) to form its odontoid process, as in us; it is now a considerable bony mass inside the thick odontoid pivot of this peculiar cranio-vertebral articulation. The *atlas* is procœlous, but in most land and water birds the cup is deeply notched for the pivot; in many of the nobler arboreal birds the cup is complete, save for a small hole through which the odontoid ligament passes to tie the process to the basis cranii.

The back of the atlas fits to the front of the axis by an almost flat-faced joint, but this is not an articulation of centrum with centrum, but of the first and second inter-centra dislocated in some degree through the arrest and tilting of the borrowed atlantal centrum or odontoid process. *Under* and *behind* that process, in that part of the base of the axis which binds on to the atlas below, another inter-centrum is seen; whilst the proper centrum (*c.*) of the axis is behind both the bony tracts seen in this second vertebra. Only post-zygapophyses are seen in the atlas, both pre- and post-zygapophyses in the axis and all the rest of the pre-sacrals. Also the hinder face of its centrum fits on to the next in the same manner as all the remainder of the pre-sacrals; the joint is "cylindroidal," the centra seeming to be *convex* behind, whilst in reality they are *concave*. A vertical section (fig. 2A) corrects what the horizontal section (fig. 4) seems to show; of course we have the exact opposite of this in the fore-face of each centrum. Thus the fore-face of a normal ornithic centrum, as is well seen in wide, flat vertebræ, is a convex condyle that rolls in the rounded groove of the one in front of it. This joint, assisted by the *yoking processes* or zygapophyses, allows, with perfect safety to the myelon, a very considerable amount of mutual movement between vertebra and vertebra. But this is only part of this delightful piece of animal mechanics. There is an annular meniscus interposed between the contiguous cartilaginous surfaces in this synovial joint (fig. 4); and this part being annular allows the suspensory ligament (*s.l.*) to pass from one to the other; this ligament is nothing more than the old notochord.

But even this is not a full account of the care with which nature has provided for the bird, in the structure of its neck—which is indeed *its one arm.* As I have already mentioned, the vertebral arteries burrow their way along the sides of the centra in the neck; and behind the *axis*, in all birds, the riblet finishes a tunnel right and left at the fore end of each vertebra. Here, as in the great Ratitæ, the topmost cervicals, the *atlas* and *axis* have, like so many reptiles, ribs up to the occiput. There was no bony riblet in the first stage (Plate IV.); here, in these cygnets, there is a small ossification right and left on both these bones.

That on the atlas (figs. 2, 3, *c.r.*^{1}) is a short needle of bone formed in a costal part of cartilage that had become imperfect. That on the *axis* (fig. 2, *c.r.*^{2}) is quite normal, like those that follow: it is a bony wedge pointing backwards, and is part of the *costal band* that ties together the upper and lower transverse processes.

I have mentioned that in the herons and some other birds there is an *antero-inferior bridge* to several of the cervicals (6 or 7) for the protection of the carotids. The ribs do not fasten their "capitulum" between two centra, as in us; and they have a synovial joint for both capitulum and "tuberculum." The latter is a gliding, the former a cup-and-ball, joint (Plate V., fig. 4, *r.*, *c.*).

Thus everything in the skeleton of birds is carried to its uttermost perfection. *They*, not *we*, are, in respect of bodily movements, the crowning forms of creation.

The dorsal vertebræ differ little from the last cervical (Plate IV., *c.v.*, *d.v.*): the *primary dorsal region*, however, has been largely taken in, to form the fore-part of the long sacrum (Plate V., fig. 11): the avian sacrum is *four regions in one.*

Finding how close the Anatidæ come to the Ratitæ in many things, notwithstanding their aquatic habits, and feeling sure that the very term "Ratitæ," as *ordinal*, is a mistake—a misleading term—I shall now show how near these forms, the duck-tribe and the ostrich-tribe, come together in the structure of their vertebral chain. Both have cylindroidal pre-sacrals, and both have ribs on the *atlas* and *axis*. Finding (from my son, Professor T. J. Parker*) that the intercentra of the atlas and axis were the same as in the Carinatæ, I looked for them in a ripe embryo of the mooruk (*Casuarius Bennetti*).† That embryo is as large as the cygnets a month old, and as much developed: its three foremost vertebræ (Plate IX., figs. 13–15) and its pelvis‡ show this.

The sectional view (Plate IX., fig. 15) shows that the odontoid process (*od. p.*) leans over the atlantal intercentrum (*i.c.*), and is scooped below where that intercalary element fits in. Then, again, by a remarkable adaptation the second intercentrum (*i.c.*) comes close behind the first; and the proper centrum of the axis only forms two-thirds of that *compound* vertebra. The two opposed intercentra are narrow transverse plates of bone, half as wide across as the contiguous centra. The cartilage is imperfect over the vertebral artery in the *atlas* (*at.*), and the riblet is not yet ossified: that on the *axis* (*ax.*) is also small, at present, but is embedded in cartilage: that on the third (*c.v.* 3.) is much larger. The common Cassowary§ has no ossified atlantal rib, nor has the Rhea;‖ but the Emu¶ has it well marked on both sides. In *Struthio*** it is seen on one side only. So that in these forms the atlantal ribs are less constant than in the Anatidæ; and it is worth noticing that in the swans the sacrum has one or two vertebræ more than in the giant African ostrich, which has only *twenty*.†† The sacral vertebræ of the cygnet (Plate V., fig. 11) do not correspond with what I find in very old specimens. I will therefore give the *vertebral formula* of each of my stages:—

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* An exhaustive memoir on the morphology of the Apteryx has been prepared by him, and will see the light, in the Philosophical Transactions, as soon as the present Paper.

† See Zoological Transactions, vol. iv., Plate LXXII.

‡ Philosophical Transactions, 1888, B., Plate LXV., figs. 8-10.

§ Mivart, Transactions, Zoological Society, vol. x., p. 28, fig. 23.

‖ *Ibid.*, p. 3, fig. 3.

¶ *Ibid.*, p. 17, fig. 14.

** *Ibid.*, vol. viii., p. 388, fig. 2.

†† *Ibid.*, Transactions, Zoological Society, vol. viii., p. 420.

——	C.	D.	D. S.	L. S.	S.	U. S.	Cd.
Cygnus nigricollis, embryo .	24	5	4	3	4	11	6 + 5
„ *olor*, one month old .	25	5	3	4	4	10	6 + 5
„ *olor*, aged	25	5	4	3	4	10	7 + 5

Thus, whilst the two first have *sixty-two* vertebræ in all, the third has *sixty-three ;* and there is a difference in each case as to the number in the different regions. A little overgrowth of bony deposit, in the case of the black-necked swan, would give it *twenty-three* sacrals, as its first caudal is partly between the ilia. This great number of vertebræ in the *Cygninæ* may be adaptive: it is manifestly Reptilian.

The great length of the thorax in these heavy wide-bodied birds has necessitated the development of three or, mostly, four pairs of ribs in the dorso-lumbar region: in a large number of birds there is only one pair. The gentle manner in which the individual vertebræ are modified as they pass from one region to another is well seen in this stage (Plate V., fig. 11). The lines of fusion of the vertebral elements in the embryo are still cartilaginous: where the uro-sacral region begins there two pairs of separately-ossified riblets (*s.r.*) are seen below the corresponding diapophyses. I find three pairs in *Casuarius Bennetti*[*] in which only two pairs of ribs are developed in front (*loc. cit. s.r.*); but these two *sacra* are very similar, and the same number of vertebræ are enclosed by the ilia in both cases. In the mooruk (*Casuarius Bennetti*), however, the first of these retains its distinctness as a dorsal vertebra.

The arrested and somewhat retrograded Ratitæ show their loss of parts and want of specialization in the caudal region. Mivart (*op. cit.*, p. 430) gives *ten* as the number of caudal vertebræ in the ostrich. I find only *eight* in the mooruk. The same abortive condition of this part is seen in the Tinamous; but in the Anatidæ, as in most Carinatæ, and especially in certain arboreal birds, it is a highly developed or greatly specialized* part; for the two first moveable joints in the caudal series become procœlous, and also acquire a joint-cavity. This is partly perfected in the swan, but is best seen in such birds as the horn-bills: the rest of this series is gently amphicœlous; the two contiguous facets are joined together by fibro-cartilage. The nobler Carinatæ with strong "rectrices," or tail-quills, have intercentra in this region to give greater purchase to the "depressor coccygis."† In the cygnet (Plate V., figs. 5, 6, 11, *i. c.*) I find *eight* of these milioline cartilages: the last three of these belong to the uropygial series: the three in the middle are the largest. These figures show how strongly these unfused caudals are like those of the Ratitæ: in the swans and their congeners their number is greater; and the uropygial piece is a highly specialized *region.*

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[*] Philosophical Transactions, 1888, B., Plate LXV., fig. 8, *s. r.*

In the adult the cervical vertebræ have a notable structure. From the third to the eighteenth inclusive, the re-entering angle between the neural arch and the retral styloid rib is largely filled in by a secondary bony lamina: thus the canal for the vertebral artery is walled in altogether in from half to two-thirds of its extent: behind, in each vertebra, the outer wall remains membranous. At the lower end of this series this plate is separated by a fenestra from that part of the wall which is formed by the open part of the riblet: thus, there is a delicate "flying buttress" running obliquely upwards and backwards from the riblet to the neural arch—a very elegant structure; and, in this manner, the canal is often protected, notably in the Cuculine types. In the swan and its congeners the wall is completest; and any cervical vertebra of a bird of this kind is easily recognized.

All the vertebræ of the swan are pneumatic, except the caudals: the cervicals, except at the two ends, are elegantly oblong, depressed more than usual, and narrowest at the beginning of the post-zygapophyses. The huge dorsals have ossified tendons on their spines and diapophyses.

Altogether, this is one of the neatest groups of the Class; but as the old sorts of the Chenomorphæ are not all extinct, the Palamedidæ still lingering in the neotropical region, the classification of these birds is upset, and the hedge set about the group is greatly injured.

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* See Proceedings, Royal Society, 1888, p. 472.

† See Macgillivray, British Birds, vol. 1, p. 46, fig. 6.

The *Sternum* and *Shoulder-girdle* of the early stage in the swan (Plate I., fig. 5), along with the wings, are remarkable for their small size at present. There must be some ontological reason for this; and putting together such facts as are patent, an approximation to the truth of the matter may be made. At present the sternum is entirely cartilaginous; it remains so, and is very small, relatively, in the large cygnets a month old. When it does ossify it is by *endostosis* at first, and the three main tracts are imperfectly distinct from each other. In fowls and struthious birds the sternum ossifies earlier and by *ectostosis*, in very definite tracts; though large-winged, the unwebbed Palamedidæ have a smaller sternum than the Anatidæ; but both groups have sternum and wings large. The most generalized of the Anatidæ are the geese, and the true land geese most of all. The largest of all, by far, the extinct Cnemiornis (Owen) of New Zealand,* and several existing forms, are terrestrial birds: the most generalized forms I have met with, judging from the structure of embryos at a similar stage as those of *Cygnus nigricollis*, are *Chloëphaga poliocephala* of the Falklands, and *Cereopsis novæ-hollandiæ* of Australia.

I therefore imagine the fore-parents of the Chenomorphæ to have been near akin to those of the Ratitæ and those of the Gallinaceous tribes—all land birds. In that case, after the dying out of the true teeth, those primordial forms, neither geese, swans, nor ducks, at that time, *acquired* the webs on their feet, and those horny *succedanea* to teeth that were needful for them in their peculiar method of gaining a livelihood, namely by straining out the mud of watery places for the sake of living food. Not the less did they *browse* and *graze*, as many of them do to this day; the most aquatic—the Fuligulinæ and the Merganserinæ—being the most completely carnivorous.

The extension backwards of the sternum in birds—the "xiphoid" or

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* This gigantic goose was fast becoming one of the Ratitæ (Transactions, Zoological Society, vol. ix., Plates XXXV.-XXXIX.; and *Cygnus falconeri* was an Anserine swan (Transactions, Zoological Society, vol. vi., Plate XXX.).

"metasternal" region*—is, in this embryo, only one-fourth as long as the whole tract: the notch between each cartilaginous tract is further forward than the insertion of the last sternal rib. The rostral process, in front, between the coracoid grooves, is small. The keel is rather acute-angular in front, and dies out behind, not reaching to the end of the median metasternal process. Only three-fourths of the costal edge has sternal pieces; these died out during development in the fore part: their vertebral counterparts are seen above as the styloid ribs of the two last cervical vertebræ. Seven cinctures are complete; the eighth nearly so; the ninth is less than half developed; and in two distinct tracts there was an attempt to develop *eleven* cinctures. This makes one figure the ancestral bird with a very long thorax. Yet in true land birds, and in the most archaic in existence, more so truly than the Ratitæ, the Tinamou only finishes *three* cinctures (*T. robustus; T. variegatus* has *four*), and it has the longest sternum of any bird; it is almost all metasternum, and yet has a large keel.† The coracoid grooves are separated by the small rounded "rostral process" in the Anatidæ: the coracoids (*cr.*), therefore, do not overlap as in many birds. The falcate scapula (*sc.*) and the strong broad-based coracoid are quite normal, and are ossifying fast: the "clavicular process," or *precoracoid root*, is small in these types. The furcula (Plate IV., *fr.*), however, is the most instructive part of the shoulder-girdle, and makes most for a kinship between these birds and the Ratitæ. In the Tinamou the furcula is simple: it has no cartilaginous nuclei ossified and fused, as in most birds, notably in the Passeres, the Rapaces, and the Pelecaninæ. In most of the Ratitæ it has died out; but styloid remnants—simple clavicles—are seen in Cassowarys and Emus ("Shoulder-girdle and Sternum," Plate XVII., figs. 3, 4). In the Palamedidæ the furcula is composed of two massive and simple clavicles fused together as in Tinamou, and forming a U-shaped bone—*quite like that which has been made out in Archaeopteryx.* The furcula of the swan is quite similar, but not so massive nor so pneumatic as in *Chauna chavaria.* The simple parosteal clavicles of Reptiles, because of their superficial, subcutaneous nature, are more variable than the endo-skeletal part of the shoulder-girdle: in Chameleons they are suppressed; and in Crocodiles only the *third* piece, the "interclavicle," is present (*op. cit.*, Plate XI., figs. 4 and 8).

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* See Lindsay: Proceedings, Zoological Society, 1885, pp. 684–716, Plates XLII.–XLV.

† Transactions, Zoological Society, vol. v., Plates XXXIX. and XLI.

Going back to an earlier stage, we see in the embryo duck (*Anas boschas*) after nine days' incubation (Plate I., fig. 5) that the scapula and coracoid are fused into one bar, which is bent upon itself *at more than a right angle:* it is *much less* so in the adult. The early position is Reptilian, and so is the continuity of the two parts (see in the "Urodeles," *op. cit.*, Plate III.). The antero-inferior bar, or "pre-coracoid," has the same arrested development as in the Rhea, Cassowary, and Emu (*op. cit.*, Plate XVII.); and the membrane that so strongly walls-in the interfurcular space has in it, above, a small patch of nascent bone, the future "furcular ramus" (*fr.*). The moieties of the cartilaginous sternum are uniting, and are sending down a small keel; the costal edge has seven sternal pieces (*s.r.*), and there is only room for *one* more on the pre-costal process—not *two*, as in the swan. The hinder half of the metasternum is membranous at present.

The Wings of the Anatidæ.[*]

In the nearly ripe embryo of *Cygnus nigricollis* the *humerus* and *ulna* are of the same length; the *manus* is one-eighth longer (Plate IV.). The ends of the main rods are still unossified, as are the carpal segments; the general form of each element is now the same as in the adult.

The proximal row of carpals has only the two normal avian pieces—the radiale[†] (Plate III., fig. 7), and the ulnare (*ue.*); the latter is evidently morphologically compound, for it has two unequal lobes, one on the extensor and the other on the flexor face of the limb.

The distal-carpals (*d.c.*^{1}, *d.c.*^{2}, *d.c.*^{3}) are still distinguishable above the metacarpals. The 1st (fig. 7, *d.c.*, *d.c.*^{1}) is small and ventrally displaced; it lies below the larger lunate 2nd segment; that piece is now fairly confluent

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[*] For bibliographical notices, see "Fowl's Wings": Philosophical Transactions (1888), pp. 385–398.

[†] The "radiale" carries a spur in Plectropterus (Sclater: "Ibis," vol. iv., 1886, fifth series; p. 300, fig. 3

with the 1st metacarpal (*m.c.*^{1}) in front; and the 3rd distalcarpal (*d.c.*^{3}) behind. This latter is mainly on the ulnar side of the manus, for the "index" and its carpal are inordinately large, and have dwarfed the parts on each side; the large round head of the metacarpal of the index (*m.c.*^{2}) is clearly seen wedged in between the 1st metacarpal (*m.c.*^{1}) and the 3rd distalcarpal (*d.c.*^{3}), and capped by its own large curved carpal (*d.c.*^{2}). The small patelliform 1st distalcarpal looks forwards and downwards towards its own metacarpal (*m.c.*^{1}), which is only one-third the length of the next, and is not yet ossified. This segment has a large proximal "trochanter," partly formed of a band of fibro-cartilage; this part, in some birds (e. g. Parra and Pluvianus), and notably in the Palamedidæ, carries a defensive spur. The 1st metacarpal has hinged upon it a "pollex" (*dg.*^{1}), nearly as large as the two last phalanges of the index (*dg.*^{2}); of course this latter has another—its proximal phalanx, and both are normal digits as to the number of their segments. In each of these digits the distal phalanx is the core of a claw. They are *ungual* phalanges; they are already ossifying at their tip, and the others have a shaft-bone.

But the proximal phalanx of the index has a flat dilatation on its hinder or ulnar edge (*dg.*^{2}); and the metacarpal of the index has, in the duck, near the top of its bony shaft on the ulnar side, a small accessory cartilage (Plate I., fig. 6, *m.c.*^{2}); the dilatation on the proximal phalanx arises as a distinct cartilage later than the main segment. The 3rd digit has a metacarpal (*m.c.*^{3}) only one-third the diameter of the 2nd; it reaches only to the bony shaft of that rod above; but at its lower end it reaches a little further down; its ends are still soft, and the upper is modelled on the extensor face into a distinct head; on the flexor face it is confluent with its own distalcarpal (*d.c.*^{3}) This narrow bar is bowed out in the middle so as to leave an interosseous space for the muscle of that part; below, it dilates a little, and then has articulated to it a *single* phalanx (*dg.*^{3}), where in a Reptile there would be *four* phalanges; this is only one-third the size of the second phalanx of the index; it is not yet ossified. Altogether, the index has overshadowed and starved the 3rd or hind-finger. As a rule, in old birds, this is the hindmost digit. There is, however, a very small remnant of a 4th metacarpal on the flexor side of the 3rd near its top (Plate III., fig. 7^{a}, *m.c.*^{4}); the accessory cartilage attached to the 2nd metacarpal is on the extensor side. I shall refer to these parts again in describing the Alcidæ.

The wings, like the sternum of the cygnet (Plate V., fig. 7), grow slowly; all there is to remark upon, as yet, is the extension of the bony shaft and the ossification of the 1st metacarpal (*m.c.*[1])

In old swans the relative, as well as the really great size of the wings, is greatly altered from that of the nearly ripe embryo; this is well seen by comparing the fore and hind limbs.

In that early stage the ulna was 17 millims long, and the tarso-tibia 27 millims. In the old white swan the ulna is 270 millims long, and the tarso-tibia 203 millims, or only four-fifths. The humerus is now 287–5 millims long, or 17·5 millims longer than the ulna. The manus is now 240 millims, or 30 millims shorter than the ulna. But in the embryo the manus, as I have shown, was one-eighth longer than the humerus and ulna, which were both of the same length.

I found, in the old white swan, the distalphalanx of the pollex 10 millims long, and that of the index 14 millims; they were, in both, straight and sharp-pointed—they had lost their *claw-form.* Thus the specialization in those birds is seen in the humerus becoming larger than the ulna, instead of being the same size, while the manus, which was one-eighth longer than both those segments, is now 30 millims shorter than the ulna, and 47·5 shorter than the humerus. The teleological bearing of this is, that the wings have largely changed their size as compared to the legs; they were only half the size—they are now much larger. The overgrowth of the humerus, as compared with the ulna, has reference to the quiet, buoyant, continued power of flight in these birds; the ulna has gained more room for the secondaries, whilst the space for the primaries, although larger, is relatively less. The humerus is the only pneumatic bone in the limbs of the Anatidæ; in *Chauna chavaria* only the ungual phalanges retain the marrow. All these things suggest that the Anatidæ were, in their remote parents, stout strong-legged land birds, with short wings, a small sternum, and with no special fitness for an aquatic life, beyond that of wading in shallow waters.*

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* Wolf's excellent figure of *Chauna nigricollis* (Proc. Zool. Soc., 1864, Plate XLI., p. 74) shows that archaic *hen-faced* "Chenomorph" in the very attitude and act of wading; its resemblance

If I were to go no further down, and no further afield, than this examination of the large embryo of the nestling and the old swan, half the interest of the matter would be still untouched. I have still to describe the early stages of the wing in the common duck, and the rare conditions of this part seen on the embryo of Chloëphaga, and in the adult of one of the Palamedidæ.

STAGE 1.—*Wing of Embryo Duck* (Anas boschas), *9th Day* (*less advanced*).

The paddle-shaped fore-limb at this stage differs but little from the hind-limb (Plate I., figs. 1, 2). There is a tendency to lobulation of the spatulate end of the limb; and this is manifestly due to the growth, along certain lines, of radiating thickenings of the tissue which are fast growing into pointed hyaline cartilages. There are, already visible, three such rays in the fore-limb, and four in the hind-limb. There is, indeed, an arrest, almost suppression, of two of the normal rays in the wing, and of one in the leg.

If these limbs be considered to be the modifications of what we see everywhere in Reptiles, it is evident that some of the rays have been smothered in their growth—probably, in some degree, by the great start that the developed parts have got.

Potentially, the seeds, so to speak, of the missing rays were duly sown; for in the case of the wing, one of the two lost rays makes a little attempt at growth, and the one missing ray in the leg does the same; but the developed parts have "sucked their verdure out."

Already, the main regions of the limb are differentiated; and the chief segments have become hyaline cartilage; the more inconspicuous elements and distal parts of the skeleton of the wing are still composed of embryonic cartilage or "indifferent tissue"; as to the larger rods, I have not overdrawn their distinctness. Whilst the muscles are still in formation, the harder tracts of tissue for their origin and insertion are already prepared. This is well seen in the humerus (Plate I., fig. 1, outside view of

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to the coots (Rallidæ), in respect of its huge toes, which are really those of a swan without the web, made the old Ornithologists (Vigors, Cuvier, &c.) put it with the Rallidæ and also along with Parra and Megapodius.

right wing) and in the cubitus (*r.*, *u.*). Distinct from these parts, but only semi-distinct from each other, are the parts that form the carpus; on the ulnar side, a large wedge of soft cartilage (*ue.*) is seen, with its sharp edge above; and on the radial side there is a thick mass (*re.*) notched both by the ulna (*u.*) and the radius (*r.*) Beyond these, at the mid line, another large mass is seen (*d.c.*^{2}), and on its ulnar side a much smaller half-distinct nucleus (*d.c.*^{3}); these both become the second and third distalcarpals. Growing forward from them, quite cartilaginous rods are seen; these, which are more and more soft towards the end, are distinctly segmented a little beyond their middle. Thus we have the large second and the small third metacarpals (*m.c.*^{2}, *m.c.*^{3}), with their sprouting phalanges (*dg.*^{2}, *dg.*^{3}) forming the second and third digits. The first distal carpal is not evident in this stage (I shall show it in the next); but the first metacarpal with its sprouting digit, the pollex, is already clearly seen.

The small rough model of a bird's-wing skeleton is to be clearly seen in this weak rudiment up to the wrist (carpus); but the three rays are the diverging, sprawling fingers of a Reptile.

STAGE 2.—*Embryo of Duck after Nine Days' Incubation* (*more advanced*).

In a further growth of the wing (Plate I., fig. 3, inside view of right wing) the sprawling of the fingers is not so great, and the softer parts are more clearly outlined; they are now almost hyaline cartilage. The preparation here figured was a stronger and larger embryo than Stage 1, but the period of incubation was the same. The elbow is now definitely bent; and, the whole structure becoming *avian*, the bird is becoming more and more, the *reptile* less and less.

What may be called the *necessary* and *normal* parts of the skeleton of the wing are all now present. These are the parts chosen beforehand by the elective affinities of the morphological force to form this—the strangest type of limb. The human arm and hand are simple and primitive, and nearly normal in comparison with this "freak," which is specialized for flying. We have only to look at the large masses of hardening cartilage that form the avian radiale and ulnare (*re.*, *ue.*) to see that they are only semidifferentiated lumps of tissue. They, as can be proved by their behaviour in certain birds, represent two or sometimes three carpals of more normal fore-limbs; the ulnare is in two lobes even now.

The three distalcarpals (fig. 3, *d.c.*^{1}, *d.c.*^{2}, *d.c.*^{3}) can all now be seen on the inner or flexor side of the wing; the first (*d.c.*^{1}) is a small hemispherical nucleus inside the junction of the second metacarpal with it distal carpal (*m.c.*^{2}, *d.c.*^{2}). The latter is a large lunate mass, curving round the head of its own metacarpal; it thrusts the third distalcarpal (*d.c.*^{3}) forward. This is an oval piece, larger than the ventrally displaced first, but only one-fourth the size of the second.

The pollex (*dg.*^{1}) shows its distal phalanx as a conical mass of soft tissue on the end of the proximal phalanx. The index (*dg.*^{2}) and the third digit (*dg.*^{3}) have only their proximal phalanges in the state of hyaline cartilage. The third digit is drawing nearer to the second, which all along has been twice its bulk, but not much longer.

Stage 3.—*Embryo of Duck, after Twelve Days' Incubation.*

During the next three days the transformation of the tridigitate paw (or paddle) into the wing has been very rapid, and almost complete as to form.

The main bones (Plate I., fig. 6, *r.*, *u.*) have acquired an ectosteal sheath, and all the elements are well solidified as hyaline cartilage: moreover, fusion of some of them has already taken place, and new parts have become differentiated. The various joints, or condyloid faces of the segments, are now fairly modelled by the process of mutual adaptive growth of contiguous parts: these are very perfect, notwithstanding the limited mobility of this metamorphosed member. The proximal carpals, the radiale and ulnare (Plate I., figs. 6, 7, *re.*, *ue.*), are now very perfectly preformed in cartilage: the radiale is a massive lunate wedge; the ulnare is a bilobate segment, with its "elbow" behind, and its longer oval lobe on the inside: it overlaps both the ulna and the third distalcarpal (*u.*, *d.c.*^{3}).

The large projecting second distalcarpal (*d.c.*^{2}) is now confluent with the first metacarpal (*m.c.*^{1}) in front, and the third distalcarpal (*d.c.*^{3})

behind: thus, its own huge metacarpal (*m.c.*^{2}) has its head inclosed in a thick cap of cartilage. Its outline, however, is quite clear; so also is that of the third metacarpal (*m.c.*^{3}); but its distalcarpal (*d.c.*^{3}) is fused above. The first distalcarpal (fig. 7, *d.c.*^{1}) is now a clear bud of cartilage, flattened on its adherent face, and placed inside the head of the second metacarpal. The first metacarpal (*m.c.*^{1}) runs parallel with the unossified head of the second; it is half the size of that head, and has a large flat "trochanter" on its proximal end; it then narrows and forms a condyle for the pollex (*dg.*^{1}). That digit, with its metacarpal, is half the length of the whole index, metacarpal, and phalanges, together; but its proximal phalanx is as long, but not as stout, as that of the second; its distal phalanx (so-called *ungual*) is almost the size of that of the index, which is nearly as large as the second or middle joint of the digit. In the pollex, especially, it is seen that the distal phalanges are not *ungual* as yet, but are lobate and flat at their free end, and represent not the claw-joint of a Reptile, but the last piece in the soft-ended finger of an amphibian.

At present, the terminal pieces of all the three digits are alike; but that on the third (*dg.*^{3}) represents merely the proximal stump of a Lizard's third fore-toe, which has four phalanges in it. The first and second digits in this wing are normal; the third is aborted.

But a much more abortively-developed digit is seen behind the third: this (*m.c.*^{4}) is a rudiment (or *remnant*) of the fourth metacarpal of a Lizard's fore-foot: it is on the flexor side of the hind margin of the third, close to its rounded and distinct top. This remnant is common in the Carinatæ: in Opisthocomus this digit re-appears as a proximal phalanx; it is, in that bird, a distal, not a proximal, remnant.

An *accessory cartilage* is now seen as a thin flap on the ulnar side of the proximal phalanx of the second digit (*dg.*^{2}): the second and third metacarpals have acquired a considerable bony (ectosteal) tract. The distal phalanx of the second digit is not so well developed on the right (fig. 6*a*) as on the left side: bilateral asymmetry is not uncommon in the wings of birds.

STAGE 4.—*Embryo of Duck, after Fourteen Days' Incubation.*

After two days more there are two new ectosteal tracts—those of the proximal joint of the pollex and of the index (Plate I., fig. 8, *dg.*^{1}, *dg.*^{2}); the other parts are similar, but larger: the first distalcarpal (*d.c.*^{1}) is growing towards its own metacarpal (*m.c.*^{1}). The difference in the size of the two lobes of the ulnare is now well seen (figs. 8, 9, *ue.*). The distal phalanges of the pollex and index (*dg.*^{1}, *dg.*^{2}) are becoming curved as ungual joints.

STAGE 5.—*Embryo of Duck, after Eighteen Days' Incubation.*

In this stage (Plate II., figs. 4–6) there are several points to be noticed. The second phalanx of the index (*dg.*^{2}) is ossifying; and the large curved distal joints of both that and the first digit (*dg.*^{1}, *dg.*^{2}) have a terminal horny sheath. In the more enlarged figures (figs. 5, 6) there are some important parts displayed more plainly: the accessory tract of the second metacarpal (*m.c.*^{2}), which is very small in the Anatidæ, and very large in the fowl tribe, can be seen as a narrow tract of cartilage growing forwards from the ulnar side of the great distalcarpal (*d.c.*^{2}). The first distalcarpal (fig. 5, *d.c.*^{1}) is now a thick band of cartilage which has grown across the head of the second metacarpal, and has applied itself to its own metacarpal (*m.c.*^{1}). In the same view the fourth metacarpal (*m.c.*^{4}) is plainly seen as a small pyriform nucleus of hyaline cartilage. On the outer or extensor face (fig. 6) the peculiar free end of the outside of the third metacarpal is also well seen.

STAGE 6.—*Embryo of Duck, just Ripe.*

In this stage I have shown the proximal end of the manus (Plate II., figs. 8, 9): it differs but little from the last; but the fourth metacarpal (*m.c.*^{4}) is becoming confluent with the top of the third (*m.c.*^{3})

STAGE 7.—*Duckling Three Days Old.*

The same parts are shown in this stage (Plate II., figs. 10, 11): the fourth metacarpal (*m.c.*^{4}) is now confluent with the third (*m.c.*^{3}): the accessory part to the second metacarpal ($m.c.^{2}$) is now a thin point of cartilage embracing the large bar on its ulnar edge above.

STAGE 8.—*Old Duck* (Anas boschas).

As compared with that of the swan, the wing of the mallard—and also that of the tame duck and of the sub-family Anatidæ generally—is relatively, as well as really, short: they are heavy birds to be carried with such wings as they possess.

In these smaller forms the cubitus is considerably the smallest of the three divisions of the wing-skeleton, and the manus the longest; they beat their wings rapidly in flight, unlike the "longipennes," birds with very long humeri. During the growth of the duckling, the carpals all acquire an endosteal centre; the two proximal segments remain free; the three distal become fused with the metacarpals, and these with each other; the second and third at both ends. The ungual phalanges of the pollex and index remain in the adult as sharp and straight pieces: the latter is the longer; and thus, besides the free synovial articulations of the two proximal carpals with the cubital bones above, and the compound manus below, the pollex has two, the index three, and the third digit one, moveable articulation permanent—just as much as is necessary in this transformed arm and hand, with its marvellous investment and its new function.

The Hip-girdle of Anas boschas.

In this species I am able to give three stages earlier than that of the nearly ripe embryo of the swan (Plates IV. and V.); and these show what transformation an average reptilian pelvis undergoes in the bird, correlatively with that of the shoulder-girdle and wing. The changes are very great in these parts, but not so great as in those.

Morphologically, the steps or stages of this metamorphic process may be said to be *four* in number: we have—1, the general Reptilian; 2, the Ornithoscelidan; 3, the Struthious; and 4, the normal Carinate stage. These stages are not so clearly defined in the hind-limbs: they are very marked in the moieties of the hip-girdle.

STAGE 1.—*Pelvis of Embryo Duck, Nine Days' Incubation (less advanced).*

This first, or Reptilian, stage of the hip-plate (Plate II., fig. 1) is shown in relation to the hinder-part of the vertebral chain, which is rapidly forming round the notochord (*nc.*), and over the myelon.

This stage is well illustrated in Miss A. Johnson's valuable Paper on the development of these parts in the Chick.* The vertebral formula of the adult duck is as follows:—

C. 16; D. 5; D. S. 3; L. S. 3; S. 3; U. S. 7;
Cd. 8 + 5 = 13: Total, 50.

Of these the last two cervicals have free ribs: and also the first three sacrals, or dorso-sacrals; and there are rib-bars on two or three—originally on five—of the urosacrals.

Now, the three true sacrals are exactly over and between the acetabula. In this first stage, therefore (Plate II., fig. 1), there are four in front of these covered by the anterior lobe of the ilium (*pre-ilium*), and three urosacrals by the posterior lobe or *post-ilium*—ten altogether, instead of sixteen as in the adult. At a still earlier stage there would be fewer,† in which stage the crest of the ilium is scarcely more dilated than the "supra-scapula," as in some Lizards (see, in Stellio, Shoulder-girdle and Sternum, Plate XI., fig. 1, *s.sc.*). It has, moreover, to be kept in mind that hosts of small and nobler birds have only *ten* vertebræ embraced by the ilia, although *eleven* is the most common number: the duck is a medium, the swan an extreme, case.

In *Iguanodon bernissartensis* there are *ten* vertebræ fairly between the ilia, as in my first stage in the embryo duck.‡ This first stage, however, has the hip-plate, as a whole, not in an Ornithoscelidan, but in a general Reptilian condition. It is instructive to see how the pre-ilium at present preponderates over the post-ilium; for it is the great development of the latter region that makes the bird's pelvis so remarkable; a still more remarkable fact being the adumbration, by the unwieldy Iguanodon, of the

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* Studies, Morph. Lab., Camb., vol. ii., Plate IV., figs. 3–6.

† See A. Johnson, *op. cit.*, Plate IV., figs. 3, 4.

‡ Dollo, Bull. Mus. Roy. Hist. Nat. Belg., t. ii., Plate V.

hip and legs of such small, light, airy forms as the nobler types of birds. Of the vertebræ that are built in between the hip-plates the last seven are, properly speaking, caudal; then follow, as a rule in this bird, thirteen more, the last *five* forming the uropygial piece. But I have seen as many as *ten* segments in that terminal region (Plate II., fig. 12); that would give *twenty-five* for the post-sacral or caudal series.* These, were they elongated as in the tail of Archæopteryx, would have formed another "Saururous" type. It is easy to imagine such a *hind-spine* as the one depicted (Plate II., fig. 1) as rapidly developing into the tail of a Saururous bird, instead of contracting itself into the stunted and largely fused uro-sacral and caudal series of a duck, or of any normal Carinate bird.

Palæontology is extremely tantalizing at this point. Geologically not so much older than Marsh's toothed birds, the Archæopteryx has no claim of fatherhood upon *them:* the gulf is not so great as between the Iguanodon and the Humming Bird; it is, however, *unbridgeable*, notwithstanding.

One more remark. In cartilaginous fishes—above all, in the Ray family—the neck becomes a *quasi*-sacrum; for the shoulder-girdle is fixed like the hips of higher forms: the fore limbs dominate the hind limbs, as they are the chief paired organs of progression.

The flying bird would seem to be relapsing in this respect, the fore limbs being its main organs of progression: but the bird is merely a land animal modified; hence its hind limbs are well developed also.

In the formation of these noble feathered forms it is instructive to see the part played by the notochord, and the rapid manner in which it becomes contracted and obscured, and then transformed into a mere ligament; in my first stage (Plate II., fig. 1), had it gone on growing and developing the vertebral segments on and around it, this bird must have soon become one of Professor Huxley's "Saururæ"; it was, however, *ordained to become* one of his Carinatæ.

By careful dissection of early embryos, Miss B. Lindsay† was able to show that the shoulder-girdle of the bird arises as three (*apparently*) separate tracts of embryonic cartilage; that is, however, prior to the formation of true or hyaline cartilage, for this tissue runs freely from the scapular to the coracoid region, thus forming one curved bar. The pre-coracoid tract only partially ossifies, and that in two ways, namely, by a rudiment growing directly from the coracoid, and often by *one* or *two* distinct cartilaginous tracts; the rest of the antero-inferior bar grows into a mere "parostosis"—the simple clavicle. But there is no parostosis in the hip-girdle: the whole structure answers to such a shoulder-girdle as that of the Amphibia, Chelonia, and of *Struthio camelus.* (See "Shoulder-girdle and Sternum, Plates III.–VIII.; Plate XII.; and Plate XVII., figs. 5, 6.) This subject is rendered difficult through the peculiar development of the hip-plate in the Dinosaurs. (See Dollo, *op. cit.*, Plates III. and V. See especially Plate III., fig. 2. In *Iguanodon bernissartensis* the pubis sends forwards a large broad prepubic bar, called by Dollo "pubis"; whilst the *already rotated* pubis—the long, narrow hind-part—he calls "post-pubis"; the term *pre-pubis* is the better for the fore-part. The ischium also, where it binds upon the post-pubis, sends down upon that bar a shorter anterior and a longer posterior process, to enclose the proper obturator foramen. Now, if these parts and processes be compared with those seen in the shoulder-girdle of certain Lizards, *e.g. Iguana tuberculata* (*op. cit.*, Plate IX., figs. 1, 2), and if the unossified free edge is supposed to be absent, then we are shown how that these plates may send out secondary bars: in the Iguana there is one large bar from the scapula, and two in front of the coracoid proper. So I interpret the processes on the pubis and ischium of the Dinosaurs. In birds the pre-pubis is often suppressed, but it has a considerable development in the Ratitæ, Tinamidæ, Gallinaceæ, and the Ground Cuckoos (*e.g.* Geococcygx, &c.). In Dollo's Plate III. the pelvis of a young fowl is figured: in it the small pre-pubis is shown to be ossified by the *ilium*, and not by the pubis. In other Carinatæ, as far as I have seen, the same thing takes place; a good instance at hand being the pelvis of a newly-hatched quail (*Coturnix dactylisonans*). In it the pubic ossification reaches the base of the finger-shaped pre-pubic lobe; afterwards the suture between that bone and the ilium runs directly inwards, as in Dollo's figure; and thus the spur receives its bony deposit from the ilium. In an earlier stage of *Phasianus versicolor* the spur is endosteally ossified, and is in front of the suture between the ilium and pubis.*

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* See Proceedings, Zoological Society, 1863, p. 1–8.

† Proceedings, Zoological Society, 1885, p. 704.

I feel certain that Professor H. G. Seeley, F.R.S.,† has unnecessarily raised a difficulty and a doubt about the pubis of the Crocodile; and that the view taken by Rathke, Hoffman (in his later writings), Huxley, Hulke, and myself, is quite right; our interpretation of this part will be found to be true. In perfect harmony with these received views are the figures given in Miss A. Johnson's Paper (*op. cit.*, Plate IV., figs. 3–6); and my own first stage in the duckling, fig. 1 (Plate II.), as compared with figs. 2 and 3, suggest the same identification, exactly.‡

In my figure of the first and second stages in the embryo duck I have shown a considerable amount of distinction between the three main parts. This is seen still better in a chick than in these embryos. In it, especially when the pubis and ischium have just rotated, the three parts are semi-segmented from one another; a deepish chink is formed, as although a piece of cardboard were nearly cut through with a knife; the chinks are filled with connective tissue cells: at the first adjustment with a high power these seem to pass through. A deeper adjustment shows an extremely thin tract of cartilage on the inner face of the object: anyhow, this is very noteworthy, showing that the root and foundation of the limb is formed of *three rays*—parts that are homologous with those that form the fore-limb.

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* In a letter from one of the best of living palæontologists, J. W. Hulke, Esq., F.R.S., received December 15th, 1887, in answer to one from me, he says:—"In your fig. 3 of a bird's pelvis you represent the pre-pubic spur as wholly iliac. The corresponding spur in Apteryx, and in *Rhea americana* certainly contains a pubic element; for its suture, in immature specimens, runs through the spur, which has thus an iliac and a pubic component."

Bearing thereon, Mivart's figure of the pelvis of a young Ostrich (Trans., Zoological Society, vol. viii., p. 437, fig. 74) shows this; but unfortunately the *cartilaginous* spur was not preserved nor figured. Yet, if that figure be compared with one of the adult (p. 433, fig. 71), it will be evident that the ilium and pubis meet in the root of the process.

† Proceedings, Royal Society, 1887, *pp.* 235–242.

‡ The embryos of the Crocodile referred to by Professor Seeley as coming from me (*op. cit.*, *p.* 24) were unfortunately too old for such researches. Two years afterwards I recovered the early stages which I had wished to put into Professor Seeley's hands.

The flabelliform ilium (*il.*) is parallel with the spine in its dilated part; but its axis is at a right angle with it: such an ideal line would pass directly between the two lesser bars, the pubis and the ischium. The former of these has now very nearly the position which is permanent in the crocodile.*

In this early stage the pubis and ischium diverge at less than a right angle: they are broad and flattish tracts composed of hyaline cartilage in their upper three-fourths, but are still in a state of "indifferent tissue" below: the angles of the ilium are in the same stage, as yet. The deep setting of the femur has stopped the growth of the cartilage, so as to show, already, a large hole in the fundus of the acetabulum.

STAGE 2.—*Pelvis of Embryo Duck of Nine Days' Incubation* (*more advanced*).

In this stage the hip-girdle embraces fifteen of the general sacral series of vertebræ; only the last appears like a pre-caudal. In a general way this condition is very Dinosaurian, for the pubis (*pb.*) and ischium (*isc.*) are rotated backwards, but are still at a great distance from the caudal spine, and are relatively very large. Afterwards (fig. 3) the pubis becomes much longer than the ischium; now it is but a little longer: in Dinosauria, as a rule, the ischium is much longer than the pubis. There is no pre-pubic spur; and, at present, besides the absence of any bony deposit, the distal parts of all the three bars are still composed of indifferent tissue. They are all free from each other behind, so that there are no "fenestræ," but a series of long notches, a sacro-iliac, an ilio-ischiatic, and an obturator notch. A comparison of this, of the next stage, and of that of the almost ripe embryo of the swan, with those of the adult Ratitæ and of the Gallo-struthious Tinamous, is very instructive as helping to throw light upon the forms that birds assumed in the olden times.

We have, however, to be very careful to sift out the specialization of arrested types; for, as a rule, existing archaic forms are in some respects more modified than the culminating types; and we must recollect that they have as long a list of ancestors, and have been as long in existence in the loins of those ancestors, as the newest and noblest forms.

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* Huxley, Proceedings, Geological Society, 1869, p. 27, fig. 3; Dollo, *op. cit.*, Plate III., fig. 1 *c.*

That the Ratitæ represent several distinct families of birds there can be no doubt; nor can it be doubted that the Tinamous are less degraded archaic forms closely allied to them. I have already shown how near the embryo swan's pelvis comes to that of the African ostrich. In this second stage of the duck the hip-plate wants but little further growth and modification to make it into one like that of the cassowary.* In a few birds (*e.g.* the Buceridæ and Picidæ) the pubis, in the adult, becomes fused with the ischium, below, as the post-ilium does normally, above. In the cassowary all these bars are fused together in the cartilaginous condition: a little further chondrification would have done this in this second stage of the duckling. Further, in the chick, at this stage, the pelvic plate is precisely like that which is seen in the adult Tinamou. All these things are to be noticed and kept in mind.†

Behind the sixteen vertebræ that are, all but one, enclosed between the hip-plates there are thirteen segments, forming the caudal series: these are terminated by the blunt end of the notochord (*nc.*).

The rapidity of this pre-natal transformation is extremely great—as great as anything to be seen in the flowering of plants. The first and second stages had both been incubated nine days; but the second had got, in some way or other, a fair day's start, as to growth, of the first; and, in this short time, the whole difference between a general Reptilian and a Dinosaurian pelvis had been effected.

STAGE 3.—*Embryo of Duck after Twelve Days' Incubation.*

Here (Plate II., fig. 3), we see how rapidly the Carinate bird's pelvis passes into its typical condition: the general size has greatly increased;

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* Philosophical Transactions, 1888, B., Plate LXV., figs. 8–10.

† See Mivart, Transactions, Zoological Society, vol. viii., pp. 385–451; and vol. x., pp. 1–52; and "Gallinaceous Birds and Tinamous": Transactions, Zoological Society, vol. v., pp. 149–241, Plates XXXIV–XLII.

the cartilage is completed, and in parts is being transformed into bone. The pre-ilium (*pr.i.*) is now broader and relatively shorter; and the post-ilium (*pt.i.*) is well ossified, and is very broad behind the sacro-ischiatic fenestra (*s.i.f.*). That space is not yet enclosed by fusion of the post-ilium with the ischium (*isc.*), but lies upon its hinder half, or nearly half; its broad, lobate hind-part lies upon the long, curved, and spatulate hind-part of the pubis (*pb.*). As in the African ostrich and the swan, the pubis of the duck and its congeners becomes greatly unlike that of a Dinosaur: instead of being shorter it is one-third longer than the ischium. Bony deposit is seen both in the pre-ilium and the post-ilium, fore and aft of the acetabulum (*ac.*), and at the lower border: the bony shafts of the pubis and ischium are rapidly elongating; that of the former remains unossified at its dilated end in the adult, and then the pubis is twice as long as the ischium: it is somewhat shorter in Stage 1, a little longer in Stage 2, and one-third longer in Stage 3. These pubic bars differ little in the ostrich and the duck tribe, except that in the latter they do not coalesce, but remain as distinct elastic supports to the oviduct in oviposition.

The Hind-limbs of Anas boschas.*

Stages 1 and 2.—*Embryo of Duck, Nine Days' Incubation* (*less, and more matured*).

My earliest stage (Plate I., fig. 2) is very nearly the equivalent of that given by Miss A. Johnson in the chick (*op. cit.* Plate V. fig. 9). It is remarkably like the fore limb (fig. 1) of the same stage, already described; but it has four developed digits, and the rudiment of a fifth.

The main rods are composed of hyaline cartilage, sharply differentiated from the surrounding tissue: the distal parts are still "indifferent" and soft. The rapidity of growth of these embryos is well illustrated by a comparison of the humerus with the femur (fig. 1, *h*; fig. 2, *f.*); for they have already acquired their peculiar form. In the next segment, the leg, the two limbs are now sharply in contrast; for the fibula (fig. 2, *fb.*) is only half as thick as the radius (fig. 1, *r.*); moreover, the inner (or pre-axial) rod in the wing is the shorter and slenderer piece: in the leg it is the outer (or post-axial), namely, the fibula (fig. 2, *fb.*). This difference and the opposite direction in which the limb is bent—the *elbow* backwards, and the *knee* forwards—show what great changes the ancestral amphibian limb has undergone.[*]

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* The reader is referred to the following Papers out of many on the subject. They will be sufficient to show that it has taken a quarter of a century to find out what are the real elements

The palæontologist will see at once how carefully the bird walks in the steps of the Dinosaurs. My figure of the skeleton of the leg (fig. 2) can be simply superimposed upon his. There is part for part, digit for digit: the nearly useless fibula, dominated by the one necessary segment of the leg proper, the tibia, is already slender and short; it is only one-third the thickness of the tibia, and its terminal part runs short of the ankle-joint: it is only five-sixths of its proper length; whilst the distal part of the tibia is dilated so as almost to reach the fibular, or outer, edge of the limb. What seems like an "elbow" at the top of the tibia is, in reality, the rudiment of the large, folded cnemial crest: this part is developed like a "trochanter," and always has its own epiphysis in a young bird. In many birds there is no other epiphysis whatever.

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of this remarkably modified limb—a limb curiously transformed from what is typical, and, what was still more unexpected, its almost perfect conformity with that of the Dinosaurs.

W. K. P.: "Osteology of *Balæniceps rex*": Transactions, Zoological Society, vol. iv., 1851–61, p. 343.

Gegenbaur, C.: "Vergleichend-anatomische Bemerkungen über das Fusskelet der Vögel": Archiv. für Anat. und Phys. Jahrgang, 1863: pp. 450–472.

Huxley, T. H.: "Dinosauria and Birds."—Proceedings, Geological Society, 1869, pp. 12–31.

Morse, E. S.: "On the Identity of the Process of the Astragalus with the Intermedium."—Anniversary Memoirs, Bost. Soc. Nat. Hist., 1880, Plate I., pp. 1–10.

Baur, G.: "Der Tarsus der Vögel und Dinosaurier."—Morph. Jahrbuch, Bd. VIII. (Taf. 19, 20, pp. 417–456.

Johnson, A.: "On the Development of the Pelvic Girdle and Skeleton of the Hind-limb in the Chick."—Stud. Morphl. Lab. Camb., vol. ii., 1886, Plates IV., V., pp. 13–27.

W. K. P.: Proc. Roy. Soc. 1887, pp. 57–58: N.B.—On p. 58, line 11 from the bottom, for "always," read "never."

[*] This is not well shown in the somewhat diagrammatic figures here given, in which the *inner* or *anterior* side is figured *behind* and *below*.

But in all birds, whilst growing, there is what seems to be a large distal epiphysis to the tibia.*

The absence of any apparent tarsal bone in existing birds has been so long taken as a fact about which there is no question, that, even now, some of my fellow-labourers are still sternly opposed to such a great primary complexity in this part, as for some years past I have been able to demonstrate.

Both in Dr. G. Baur's figures of sections† and in the figure, just referred to, of Miss A. Johnson there is no sign of a cartilaginous intermedium, such as I have figured in my first and second stages (Plate I., figs. 2 and 4, *i.*). Happily, however, they both show the distinctness of the *tibiale* and *fibulare*, and also the proximal rudiment of the fifth metatarsal. My preparations of these parts in the duck's embryo were made in the early part of 1887: those of the chick in a stage equal to that of Miss Johnson's fig. 9 were made a year before. After lying in oil of cloves for some months all these preparations were mounted in Canada balsam: they show still more clearly now what I discovered then. In Dr. Baur's method—by *sections*—nothing would be easier than to miss the thin intermedium; for it lies *above* and considerably in *front of* the tibiale and fibulare. Both under a lower and a higher power it can be clearly seen as a thin pyriform cartilage, with its broad end below, and lying in front of the fibrous lower end of the fibula (*fb.*). The *tibia* (fig. 4, *t.*) soon gets behind it, as it becomes very much dilated below.

When the microscope is adjusted so as to show the tibia, fibula, tibiale, and fibulare (Miss A. Johnson's fig. 9 shows this well), then there is no intermedium to be seen. The gentlest elevation of the object glass, however, makes all these parts cloudy. And now the intermedium comes clearly into view: it may easily be mistaken, even then, for a part of the dilated base of the tibia. Now, as this distinct tract of cartilage becomes ossified by *ectostosis* at about the middle of incubation; and, as the tibiale and fibulare are still *mere endosteal nuclei* in the centres of the cartilage in cygnets one month old, how can the ascending process be a mere outgrowth, or periosteal addition, to either the tibiale or fibulare, or both parts, which have no such periosteal structure possible until the bird is fairly adult? Also, to which of these tarsals does it belong? and why do they develop this *tibial clamp*, seeing that they must so soon be fused with the main bone?

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* My figures of this *pseudo-epiphysis* in an emu chick, six weeks old, were made in the year 1842. After much meditation upon this anomalous structure, I, at length, timidly suggested that this part was, in reality, the *astragalus*, and not an *epiphysis*.

† "Der Tarsus der Vögel und Dinosaurier," Plate XX.

Another question arises, namely, *is it a tarsal* bone?—was it not a *third shaft-bone* in the leg of the old ancestors of the reptiles and birds? As cartilage, it arises earlier than the tibiale and fibulare—as bone, much earlier; and its mode of ossification is not that of any tarsal (or carpal) that I know of.*

At present the fibulare (*fbe.*) is a round nucleus of soft cartilage, only one-third as large as the transversely-expanded tibiale (*te.*). This is well shown in the chick in Baur's sections, and in Miss A. Johnson's dissection.

The distal part of the tarsus is in a very undifferentiated condition. Only one nucleus can be traced (*d.t.*): this appears over the middle of the perfect metatarsals ($m.t.^3$); it then grows right and left as a horizontal wedge. The most evident subdivision of this piece is to be seen in nestling sparrows (*Passer domesticus*) when the bony deposit is in these lobes. Belonging to the 2nd, 3rd, and 4th metacarpal, this piece corresponds with the inner part of the "cuboid," and the outer and middle "cuneiform" bones of one foot. But in our foot there is an element called the "scaphoid": it is wedged in between the astragalus (*tibiale*) and the three cuneiform bones. This element is more or less developed, generally, in embryo birds: in fowls, struthious birds, and Tinamous, and in arboreal birds generally, it becomes ossified, and serves as a *sesamoid* to the plantar tendons. Morse (*op. cit.*, Plate I., fig. 8) figures it in the embryo of the Eider duck, and puts a ? to it.

It is not quite distinct even in my second stage; but I shall describe it in the 4th. This nucleus is found in the large interarticular plate, which is seen between the proximal and distaltarsal masses in the inner (*tibial*) side of the joint, and becomes thrust backwards when the ankle is complete: the scaphoid is a *centrale*. This part was first seen by me to have this interpretation early in 1886; and soon afterwards (independently) by my son, T. J. Parker, in the embryo of the *Apteryx*. It is very large in the adult *Buceros ruficollis*, and is permanently anchored to the large interarticular fibro-cartilage. Even in the adult, where it serves a sesamoidal function, it is permanently fixed between the astragalus and the part which answers to the middle cuneiform bone.*

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* I greatly rejoice over the work of my young friends, whose views are criticized above; but I have spent *years* over this kind of work, where they have spent *weeks*. There is such a thing as "personal equation" to be made account of in scientific research; and there is such a state of mind in some workers, that they believe in no eyes but their own.

These two stages (Plate I., figs. 3, 4) show how the fore-paw of a reptilian form begins to take on the ornithic characters. In its utmost specialization (the whole limb becoming single down to the toes, and then supported on four, three, or even two of these), the leg and the shank being, as in the flamingo and stilt plover, extremely elongated; and yet, so exquisitely hinged and upheld, that one limb alone is sufficient for the firm support of the whole body. This last result of the avian transformation cannot be too much admired. Nor are the varieties of the avian leg and foot less excellent in this class, each member of which is a cunning gymnast. Here in the duck we have the beginning of that modification of the hind limb which has attained its utmost perfection in the loon (Colymbus). Already, in stage 1, the hallux, or 1st digit, is being carried away from the tarsus; in stage 2, its arrested metatarsal (*m.t.*^{1}) is attached to the middle of the next (*m.t.*^{2}); still, even in this stage, the toes are sprawling, and their metatarsals are free and diverging. In stage 1 the digits (fig. 2, *dg.*$^{1-4}$) are soft, and their phalangeal segments very undefined; in stage 2 (fig. 4) these are hardening and sub-dividing: the remnant of the 5th (*m.t.*^{5}) can now be seen as a globular mass of softish cartilage. Had it been developed with three or four phalanges at its end, the reptilian foot would have been complete.

Even in the second stage the toes are amphibian as yet; and the general web, which is retained for all but the 1st digit, is simply the common expansion of the paddle, or hind oar, of a low, swimming creature.

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* See T. J. Parker, Proceedings, Royal Society, 1888, p. 487; and W. K. Parker, *ibid.*, 1887, p. 58.

STAGE 3.—*Embryo of Duck, after Twelve Days' Incubation.*

In three days' growth the sprawling reptilian foot becomes almost typically *ornithic:* it is typically *ornithoscelidan.* What concerns us most now is the further and further marking of the elements of the ankle-joint and instep, tarsus and metatarsus. The bony shaft of the tibia (fig. 10, *t.*) is creeping along the cartilaginous rod; the fibula, also, and the femur are ossifying. In the figure, the parts that form the ankle-joint are shown in a dislocated state for illustrative purposes. As yet the tibia, proximal tarsal, and distal-tarsal masses, and the metatarsals (fig. 10) are all distinct; but the three elements of the proximal tarsal row are all fused together: the distal was always undivided. The tibia, having starved the fibula, is dilated below and deeply grooved, with extensor tendons in front: it is gently concave behind. The curious knuckle which is strapped to it below has a double condylar face below, and is like two heavy wheels joined by a broad axle. This part is hollowed out, right and left above, for the lobes of the tibia to fit into; while towards the outer (or *fibular*) side, there runs upwards a long tongue of cartilage, which is bound to the front of the outer tibial ridge; actually, this band reaches to the tibial ectostosis. On its tibial side it has a square but convex bridge of newer and softer cartilage attached to it, which passes over the deep *tendon valley* of the tibia.*

In the Papers, above referred to, neither Gegenbaur nor Huxley seem to have dreamed of there being more than the *astragalus* in the large proximal tarsal mass. The latter says (*l. c.*, p. 29) of this part in the fowl:—"The astragalus is a much depressed bone, with a concave proximal and a convex pulley-like distal surface. A process ascends from its front margin in the groove in the front face of the tibia. This process is comparatively short, and perforated by two canals for the *tibialis anticus* and *extensor communis* in the fowl; while in the ostrich and emu it is extremely long and not so perforated." Note here that the later band of cartilage had already become ossified and fused with the short ascending process in the pullet's leg described by Professor Huxley; and here again the anatine type is seen to correspond with the struthious, and to differ from the gallinaceous. I trust that these figures and descriptions of mine will at least suggest to the palæontologist that he is not observing the *primitive condition* of the limbs of Dinosaurs, nor, indeed, of the remains of any *adult* extinct reptile whatever.

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* In my Memoir on *Balæniceps*, p. 343, I erroneously ascribed the formation of the tendon bridge to the "ascending process" of the astragalus.

If, in the development of a duck's leg, such a complete fusion of the three primary proximal tarsals takes place in three days (Plate I., figs. 4 and 10), surely some allowance may be made for the pre-natal transformation of an ornithoscelidan reptile. It is seen here (fig. 10, *tb.*, *fbe.*, *i.*) that the lesser fibulare has become completely fused with the larger tibiale, and the intermedium with both: these three were all equally independent of each other. The long tongue-shaped intermedium (*i.*) is united with the fibular part of the common mass by a shorter, and to the tibial parts by a longer tract of cartilage. The scaphoid, or centrale (*c.*) is a lunate wedge of cartilage behind the tibial side of the joint, and is not, in the duck, formed into solid cartilage as it is in the fowl. The great distaltarsal (*d.t.*) has become completely formed, so as to show two concavities above for the condyles of the proximal piece, and also a rounded intercondylar process to fit into the hollow in the front of the upper piece; behind, it has sent down four ridges, the larger on the tibial side; these form the tendon-bridges and pulleys (fig. 11). The three main metatarsals ($m.t.^{2-4}$) are seen now to be closely applied to each other, and to be ossifying; their round tops fit into three concavities in the base of the distaltarsal. The fifth metatarsal ($m.t.^{5}$) is still to be seen as a small nucleus of cartilage: the first has not been figured; it has got down nearly to the end of the shank. Even the condyle of the second, however, is higher up than either that of the third or the fourth. This is an adaptive condition having relation to the aquatic habits of the bird.

STAGE 4.—*Embryo of Duck, Fourteen Days' Incubation.*

In this stage the intermedium (Plate I., fig. 12, *i.*) is still unossified; but this process begins directly after this time, that is on the fifteenth day, or at the middle of the period of incubation. The tibia (*t.*) is still distinct from the mass below; the centrale can be seen as a definite nucleus; the fifth metatarsal ($m.t.^5$) is now confluent with the fourth.

STAGE 5.—*Embryo of Duck, Eighteen Days' Incubation.*

The ossification of the intermedium, which began on the fifteenth day, is now nearly perfect, only the connective tract at the base being soft. The ectosteal tract (fig. 13, *i.*) begins as a thin bony ring round the bar, below the middle, and rapidly runs to the apex below it: the tibiale and fibulare (*tb.*, *fbe.*) are still unossified, and are still free from the tibia, above: the toe of the pedate base of the intermedium bounds the round intercondylar concavity in which the knob of the distal tarsal fits: the tendon bridge over these is now well developed.

STAGE 6.—*Duckling, Three Days old.*

In the middle of the first week after hatching, the sections through the ankle-joint show a bone in each of the pulley-like elevations of the proximal tarsal mass; and also one in the centre of the great distaltarsal. The tibia is still distinct from the former, and the metatarsals from the latter (Plate I., figs. 14, 15, *t.*, *tb.*, *fbe.*, *d.t.*, *m.t.*).

In one figure (14) the tibiale is cut through, but the lower bony centre is not reached; in the other (15), both the fibulare and the metatarsal centres are exposed; these are all three of the normal kind of bony deposits for these short segments of the limb. They are "central endostoses," and are a long while coming to the surface; so that, if the ascending process were in reality a mere periosteal growth of the double proximal tarsal, two things would have to be proved concerning it: firstly, that it did not appear until the bird was fully adult; and, secondly, that it had not its own osseous centre. The merest tyro in anatomy knows that this is true. In the duckling of the first week the "centrale" has degenerated into a mass of fibro-cartilage, forming part of the tendon sheaths at the back of the joint. Water-birds do not conserve this element as an ossified and distinct piece.

The Hind-limb of the Swans (*Cygninæ*).

In the almost ripe embryo of *Cygnus nigricollis* (Plate III., fig. 8, and Plate IV.) the ankle-joint is quite like that of the fifth stage of the embryo duck, except that the intermedium (*i.*) is shorter. After hatching, the growth of the swan's young is evidently slower than that of the duckling—cygnets of a month old being not much more advanced in this respect than ducklings of the first week. Happy in the possession of two of these, which were about equal in size to a teal (*Querquedula crecca*), I can show that, whilst the intermedium begins to ossify by the middle of the incubating period, the central endostosis, forming the rudiment of the tibiale, fibulare, and distal tarsal, has only reached the perichondrium at the end of a month after that period (Plate V., figs. 8–10); no periosteal deposit is possible as yet; and, even afterwards, the double mass (when the tibiale and fibulare are completely fused) is covered with articular cartilage, except where it has become fused with the tibial shaft-bone. Thus, the formation of the ascending process, as a *periosteal outgrowth*, is impossible.

The rest of the hind-limb in the swan, and in the Anatidæ generally, is constructed for swimming, and even for diving, in the ducks, and especially the mergansers. The two inner and larger post-tarsal ridges form a bridge over a flexor tendon, as in the fowl: the tarso-metatarsus is compressed laterally: the fourth digit is elongated, the second and first elevated, and the latter is small and free.

Wing of Embryo ($\frac{3}{5}$ *ripe*) *of Falkland Island Goose* (Chloëphaga poliocephala).

When Dr. R. W. Shufeldt called the displaced first distal tarsal "pentosteon," five carpals were known in the young bird; although, in almost every case, only the two proximal pieces remain distinct.

Dr. Morse[*] satisfied himself that the so-called "ulnare" was a double nucleus. And he was right: it is so, morphologically; and is, not unfrequently, actually subdivided into two, or even three nuclei. In a Paper, soon to be printed,[†] I have shown that the "radiale," also, may be in two pieces: for a time it is so in Opiosthocomus, the subject of that Paper; and I find it so, also, in *Falco tinnunculus.*

The subdivision of the ulnare is seen in two of the most terrestrial forms of the Chenomorphæ, namely, in this goose and in the screamer (*Chauna chavaria*). This is the more interesting, because the long-legged terrestrial geese are very apt to have spurs on their wings (*e.g.* Chenalopex, Plectropterus); and these spurs have their highest development in the unwebbed Palamedidæ—birds with cultrate bills. Thus, whilst on one hand the Chenomorphæ are walking, or, at most, wading birds; on the other, the mergansers have certainly a smack of both the cormorant and the diver in their nature. This makes it extremely difficult to conceive of the whole bundle of Chenomorphæ as branches of one stem.

In the embryo of *Chloëphaga poliocephala* the claws are well developed in the wing (Plate V., figs. 12 and 13), that on the index ($dg.^2$) being especially long. The parts at the lower hinge of the wing are as remarkable for their great number as these parts in an adult bird generally are for their fewness. The radiale (*re.*) is single; but the thick U-shaped ulnare (*ue.*, $c.^1$, $c.^2$) has both its crura segmented across, almost perfectly, to form an outer and an inner "centrale" (fig. 14, $c.^1$, $c.^2$). At this stage the three distalcarpals ($d.c.^{1\text{-}3}$) are clearly marked out; and on the edge of the third metacarpal, on its flexor side (figs. 14, 14ᵃ), there is a distinct rudiment of a fifth metacarpal (*m.c.*^{5}). On the proximal part of the second metacarpal, at the outer face of its ulnar edge, there is a distinct semi-lanceolate accessory cartilage (*m.c.* 2^1): the accessory part to the proximal phalanx of the digit (*dg.* 2^1) has coalesced with the main piece on its ulnar side, and is ossified by it, not independently. The sub-division of the ulnare is not so evident on the *right* side as on the *left*. When the spur is formed on the "trochanter" of the first metacarpal (*m.c.*^{1}) in some of the geese, there is in this case a considerable tract of fibro-cartilage ready for any such adaptive growth.

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[*] *Loc. cit.*

[†] In the Transactions, Zoological Society of London.

Whilst the peculiarities of this embryo, and of that of the kestrel, were the only types in which I had seen this remarkable sub-division of the radiale in one, and of the ulnare in the other, they caused me much anxiety: now I find that this is not so rare a condition as I had supposed.

But for a quarter of a century I had been aware of a divided "ulnare" in *Chauna chavaria*. In that bird, on the left side, there are two proximal carpal bones attached to the ulna (Plate II., fig. 13, *ue.*, *c.*): the outer is the *outer centrale*, and the inner is the "ulnare" proper: this is one-third larger than the other. Here, again, this peculiarity is seen on the *left* side, and not on the right.

In the other Palmipeds we shall see parts of the wing-skeleton that have hitherto been quite unnoticed. We are only just waking up to the fact that the things that now are have not been so always since the foundation of the world.

In the cultrate Palamedidæ, and in some of the lamellirostral forms, the wing has *spurs* similar to those on the shank of the Phasianidæ. Dr. Sclater* quotes, with approbation, the views of Mr. J. Amory Jeffries.† His words are:—"Mr. Jeffries shows definitely, for the first time so far as I can make out, that the spurs which are in some cases found on the wings of birds are of an entirely different nature from the claws also met with on the same organs, and have in fact nothing whatever to do with them." In a note on this same page, Dr. Sclater says:—"Even so recent an authority as Dr. Selenka* has confounded together the spur and claw of birds. His account of the subject contains several serious misstatements, and is obviously not based on his own examination. Owen's 'Anatomy of Vertebrates' (*cf.*, *op. cit.* II., p. 74) likewise confounds claws and spurs. It must be even admitted that Nitzsch (usually a model of accuracy, and the first scientific describer of the claws of birds) did not quite understand the differences between claws and spurs."†

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* Ibis, 1886, p. 147.

† "On the Claws and Spurs on Birds' Wings": Proceedings, Boston Soc. Nat. Hist., vol. xxi., p. 301.

I must also, myself, confess to having confounded claws with spurs in my Paper "On Balæniceps,"‡ and also in that "On Gallinaceous Birds and Tinamous,"§ I have put the hallux as the *second toe*, considering the spur of the cock to be the abortively developed *first toe.*

That error was corrected by Gegenbaur,|| and his views were adopted by Huxley.¶ The hind-toe or hallux does certainly correspond with the innermost, or first toe, in a lizard's hind-foot, just as the pollex of the bird corresponds with the innermost digit of the fore-foot of a lizard. The normal number of phalanges determines this, namely from *two* in the first to *five* in the fourth, and then a diminution in number in the fifth.

But this matter cannot be settled and made sure for ever to science by the study of adult birds. If Dr. Sclater had compared the wing of *Chauna derbiana* (*op. cit.*, p. 150, fig. 2) with Dollo's figures of *Iguanodon bernissartensis*,** or even with some of my figures of the early state of the digits of the wing,†† his sense of certainty would have yielded to the confusion of

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* Bronn's "Thier-Reich": Aves, p. 75.

† See his "Osteographische Beiträge, No. 5": Ueber das Nagelglied der Flügelfinger, besonders des Daumens: Leipzig, 1811.

‡ Transactions, Zoological Society, vol. iv., Plate LXVI.

§ *Ibid.*, vol. v., Plate XXXV.

|| "Vergleichend-anatomische Bemerkungen über das Fusskelet der Vögel": Archiv. für Anat. und Phys., 1863.

¶ Proceedings, Zoological Society, 1867, p. 417.

** Bull. Mus. Roy. Hist. Nat. Belg., t. i., Plate IX., figs. 2, 3.

†† Philosophical Transactions, 1888, B., Plate LXII., figs. 1, 2.

mind attributed by him to Owen and Nitzsch. In that huge extinct reptile, with its extremely avian hind-quarters, both the pollex and the fifth finger diverge at a right angle from the rest. If the horn-core and the small bone at its base had been anchylosed to the other parts, nothing would have appeared more certain than the precise homology of that pollex with the upper spur in Palamedea and Chauna. The difficulty does not, however, cease here. In a continuation of his valuable Paper,* Dr. Sclater shows that the large spur on the wing of the spur-winged goose (*Plectropterus gambensis*) is on a projection of the radiale, or inner proximal carpal. Nothing, to those who are satisfied with *adult anatomy*, could be clearer than this proof that the spurs are of an entirely different nature from the claws also met with on the same organs, and have, in fact, nothing whatever to do with them.

But we must, as the saying is, "go slowly that we may make the more speed." I would remind Mr. Jeffries and Dr. Sclater that, in the evolution of the cheiropterygium from the ichthyopterygium, *claws are a late specialization.* Only Dactylethra, amongst existing Amphibia, possesses them. In the Reptilia, as in Dactylethra, the *straight nailless terminal phalanges* grew out into the skin-fold, and there received a horny covering, both the dermal layer and the terminal phalanx becoming covered, and so forming a hooked claw.

But the normal digits of the highly specialized pentadactyle cheiropterygium are not the only parts we have to deal with in the limbs of birds and mammals. Neither birds nor mammals are the descendants of *true* reptiles, but of much more ancient and generalized types.

I find, taking the birds as a whole—in this bird and in that—a row of cartilaginous nuclei inside, or in front of, the normal first digit, or pollex. These I shall describe in a Paper succeeding the present. Not only these segments of a "pre-pollex," but intercalary segments are also common in the developing wing of a bird—feeble forkings of the digits; a reappearing, or rather a *lingering*, of vestiges or remnants of some archaic polydactyle limb. In the common fowl the core of the cock's spur is at first a solid fibro-cartilage—a "pre-hallux": it fuses with the second metacarpal after it has become ossified.

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* Ibis, 1886, pp. 300–301, fig. 3.

Now, the presence of two spurs on the same limb in the shank of Polyplectron, and in the wing of Chauna,* seems at first blush to decide the merely *adaptive* and, as it were, *accidental* nature of these spurs. My answer to this is that there are two phalanges which appear between the pollex and index in birds; and that the distal of these two segments is present in by far the greater number of Passerine birds. That segment is a triangular plate of true hyaline cartilage, autogenously ossified by *endostosis*, and becomes fused with the *ectosteal sheath* of the second metacarpal, near its lower end; and is manifestly the true homologue of the horn-core of the distal spur in the Palamedidæ.

THE ALCIDÆ.

This palæarctic family, which has only lately lost its chief—*Alca impennis*—is still rich in forms ranging in size, if we take in the great lost species, from a large goose to a small gosling; for *Ciceronia pusilla* scarcely exceeds the size of the latter.

These birds are the *isomorphs* of the nearctic penguins (Spheniscidæ); and, in the case of the great auk, the approach of the northern to the southern type was very close.

As to the penguins, they are a much more isolated type than the auks and guillemots, and are also much more uniform. Specialized to the uttermost in one direction, they are nevertheless evidently *archaic*. The tendency of the Alcidæ is in the same direction: they appear, however, to have begun to modify in this direction later than the penguins, and the transformation is only partial. This, however, is pure conjecture. Professor Huxley's "Classification"† breaks down most among these water-birds. His "Cecomorphæ" are a promiscuous flock of Palmipeds driven together by the "whiff and wind" of his taxonomic force. If it pleases him to call the group the gull-form, he must not be surprised if the next classifier should scare them all apart again.

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* Sclater, *op. cit.*, p. 150, fig. 2.

† Proceedings, Zoological Society, 1867, pp. 415–472.

Dr. Marsh did this unconsciously; for his toothed birds show, if they show anything (and they are the most lucid revelation we have had on this subject as yet) that the divers and the gulls were as far apart in the secondary epoch as they are now. The Ichthyornis is evidently an archaic toothed gull; and the Hesperornis, which anticipates the modern terrestrial Ratitæ, has, like its nearest living relatives, the grebes and loons (Podicipitidæ, and Colymbidæ), cylindroidal vertebræ down to its sacrum. Ichthyornis, a Carinate, has its pre-sacrals amphicœlous—a condition scarcely improved upon by the existing gulls in their hinder dorsals: their cervicals are cylindroidal. This modern group of the Alcidæ, like the existing gulls, have opisthocœlous dorsals; and so have the penguins and the plovers, the cormorants and the darters; but grebes and loons, like Hesperornis, have the whole pre-sacral series cylindroidal; in which they agree with the modern Ratitæ on one hand, and with the petrels and all the "Steganopods" or Tolipalmatæ, except the cormorants and darters (Phalacrocoracidæ) and Plotidæ.

In respect of the dorsal vertebræ the Alcidæ and Laridæ agree, and their skull* is very similar fundamentally; but so, also, is that of the aberrant Limicolæ, *e.g.* Chionis, Attagis, and Thinocorus; and the Rallidæ, also, come very close in this respect. The fact of the case is that, in great numbers of those schizognathous birds that abort their basi-pterygoids, there is a wonderful conformity in this respect.

But the skull of the penguins is also one of the same type; it is somewhat more archaic certainly; but there is nothing in that part, nor in the rest of the bird, it seems to me, sufficient to warrant the separation of that one family into a sort of order—the "Spheniscomorphæ"—whilst gulls, skuas, petrels, auks, guillemots, loons, and grebes are put together by force into a sort of "happy family": their harmony will end the moment the personality of the "keeper" ceases to dominate them.

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* See Huxley, *op. cit.*, p. 430, figs. 10, 11.

In some respects the gulls and auks agree; they are as unlike, on the whole, as it is possible for two groups of water-birds to be.

THE MORPHOLOGY OF THE ALCIDÆ.*

The Cranium in Uria troile.

STAGE 1.—*Skull of Embryo of* Uria troile, *One-third ripe.*

The chondrocranium, at this stage, is fully formed (Plate VI., fig. 1). The basal part is the most instructive; the other regions will come under notice in the more advanced stages.†

The transitory, as well as the permanent, parts of the endocranium are well developed; much of the latter will undergo osseous transformation. The chondrocranium, at present, has some little likeness to that of a skate, the skull proper being so short, and the pre-nasal rostrum so long; but this is a high skull, like that of a perch, and that of the skate is a low one. Here the brain is tilted upwards in front, and lies on the coping of a large wall: in the skate, as in the Amphibia, the brain lies down on the flat basi-cranial floor. The chondrocranium has not yet begun to ossify; the notochord (*nc.*) is still large; but the parachordal tracts have united across it, have coalesced with the cartilaginous ear-capsules, and have sent upwards lateral growths that have met, right and left, and become confluent, over the hind brain. Behind, the double tract of cartilage has formed the almost hemispherical occipital condyle (*oc.c.*); and, in front of this, and further outwards, we see the passages for the hypoglossal (xii.), and vagus and glossopharyngeal nerves (ix., x.).

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* For the osteology of the same parts of the embryo of Alcidæ, see my "Shoulder-girdle and Sternum" (Plate XVII., figs. 10–14, pp. 146–148); and of the adult bird, see Owen, "On *Alca impennis*," Transactions, Zoological Society, vol. v., Plates LI.–LII., pp. 317–335; and R. W. Shufeldt, "Osteology of Arctic and Antarctic Water Birds."—Journal of Anatomy and Physiology, vol. xxiii., Plates I.–V., pp. 1–39; *ibid.*, Plates VII.–XI., pp. 165–186; *ibid.*, pp. 400–558.

† For figures and descriptions of the very similar skull of *Gavia ridibunda*, see Transactions, Linnean Society, series 2, vol i., Plates XXVI.–XXVII., pp. 140–151.

The auditory capsules occupy a very large space in the sides and base of this delicate semi-transparent chondrocranium. The lagenæ (*au.*), and the canals (*a.s.c.*, *h.s.c.*, *p.s.c.*) shine through the thin, clear walls. In front of these capsules the base of the skull suddenly closes in; the notochord is lost to view, for it ascends into the post-clinoid wall (see in stage 3, fig. 8, *p.cl.*). In front of that wall there is a round opening—the pituitary space, which receives a secondary floor, but is not, as in our cranium, floored with cartilage—the seat of the "sella turcica." That open hole was formed by the growth of the trabeculæ round the pituitary involution; there they met, and coalesced with, the parachordals or investing mass enclosing the notochord behind. Meeting in front of this open space, the trabeculæ run forwards, and, *apparently*, at this stage, form the long, thick, rounded balk of cartilage which runs forwards to the end of the beak. But a little in front of the pituitary space there was formed a median cartilage, which wedged itself in between the other two, and can therefore be fitly called the *intertrabecula*. The paired trabeculæ only run half way to the end; flattening out, they grow upwards and help to form the orbito-nasal partition wall (see, in 3rd stage, fig. 8, *tr.*, *p.e.*, *s.n.*). The trabeculæ, in some cases, send out flat cornua where they end.* I do not see these parts in Uria. The foremost third of the long wall is free; it has no wall growing upwards from it: it is a large *Raïine pre-nasal rostrum*. Just when it is becoming free, it is somewhat twisted, as also is the primary mandible below (fig. 2, *mk.*). I shall refer to this in the next stage. The large alisphenoidal, and the aborted orbito-sphenoidal wings will be described in the 3rd stage (fig. 8, *al.s.*, *o.s.*).

Instead of the direct basi-cranial outgrowths for articulation with the pterygoids, as in lizards and the Ratitæ,† these birds, like the fowl and most other Carinatæ, develope separate *remnants* of those basi-pterygoid outgrowths (fig. 1, *b.pg.*). In these, and many other birds, these parts, and the joint formed by them and the pterygoids, is only a temporary structure; and in many of the passerines the remnants themselves are suppressed.*

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* See in Chick, Philosophical Transactions, 1869, Plate LXXXIII., fig. 4, *s.v.l.*

† See Philosophical Transactions, 1866, Plate VII., figs. 2 and 4, *ap.*

The pier of the first visceral arch—the quadratum (*q.*)—is a large segment, and very amphibian in the bird, as in the Chelonia. Here we see that its pedicle or primary swinging point, the orbital process is free and rounded; its secondary head, or "otic process" is large and bilobate, obliquely. Below, the short, thick, main bar ends as a sinuously convex condyle for articulation with the next segment of this inverted arch—the articulo-meckelian rod (fig. 2, *m.k.*). That rod, right and left, is almost as solid as the great cartilaginous skull balk: it is a long, terete, sinuous rod, gently lessened in front, rounded at its end, and lobate and scooped behind for articulation with its own upper segment: it has, like its counterpart in the marsupial Mammals (the future malleus), both an internal and an external angular process (*i.a.p.*, *p.a.p.*). The meckelian rods do not coalesce distally, or in front, as they do in the Mammalia, but remain free as long as they exist, as in lizards and snakes.† In morphological language, the quadrate is the first epi-branchial, and the articulo-meckelian rod the first cerato-branchial. They were gill arches.

The second visceral arch—the hyoid—is half suppressed. Its uppermost segment, as in the Amphibia and Reptilia, has been dominated by the organ of hearing, and is aborted and specialized: this part is the columella (fig. 1, *co.*): it has a dilated proximal, and a trifid distal end. In morphology it is a pharyngo-branchial segment. In some birds a distinct epi-branchial segment is formed, and coalesces with the lower ray of the columella—the "infra-stapedial": distally, the cerato-hyal appear in the hypo-hyal region. The right and left cerato-hyals (fig. 3, *c.hy.*) are terete, lessen forwards, and meet each other in the sagittiform tongue. Between and behind these the old basi-branchial reappears (*b.br.*): it is thickest towards the front, and lessens behind, where it ends

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* Monthly Micr. Jour., March 1st, 1873, Plates VIII.–X.

† Philosophical Transactions, 1878, Plates XXVIII., XXIX.; and *ibid.*, 1879, Plate XLI., fig. 3, *mt.*

free and pointed: it represents several median segments. One branchial arch, which answers to the first gill-bearer in osseous fishes (fig. 3, *br.*[1]), is developed. It is in two segments; the larger is the distal; this is ossifying: the lesser is still soft, and is free above; it curls round behind the occiput. I have not described the nasal capsules in this stage: I shall refer to them in the next.

The ectocranium, at this stage, has all its primary centres of ossification started: they are creeping tracts of osteoblasts forming in the subcutaneous web, and are very similar in character, in form, and in relation to those which are formed in the chondrocranium of an osseous fish. Indeed, it is with the Ichthyopsida generally, and not with the existing Reptiles, that the developing skull of a bird has to be compared, if its interpretation is to be made sure. Yet, no osseous fish or existing amphibian, and no reptile now living, has such an extremely prognathous face as this. As the primary pterygo-palatine arcade (*pg. pa.*) is almost entirely suppressed, the pterygoids and palatines are here reduced to the condition of mere parostoses like the premaxillaries, maxillaries, jugals, and quadrato-jugals (*px. mx.*, *q. j.*). All *ascent* in the Vertebrata skull is attended with the fading of the chondrocranial parts, and the flourishing of the ectocranial elements. The dominating splints of the upper face are the premaxillaries (*px.*), as in typical osseous fishes: these use the Raiine pre-nasal rostrum (*p.n.*) as a model, then destroy it by their own overgrowth. The maxillaries (*mx.*) are mere "ossa mystacea" lying behind and within the premaxillaries: they have already formed an angular process, the part that overlaps the jugal arch, and also their palatine process—maxillo-palatine (*mx.p.*)—a curved retral style, with its curved outline inwards. Between these two processes the palatine (*pa.*) sends its styloid fore-part: it then dilates, bends outwards, and sends inwards an ascending process to bind upon the basis cranii, and with its fellow to hold the vomer as in a vice. Overlapping the inner side of these bones, behind, we see the falchion-shaped pterygoids (*pg.*) that are already cupped at their other ends, and are fitted to the knob on the quadrate: this knob is a small stump of what was, in the ichthyopsidan ancestor, a long pterygo-palatine cartilage. The quadrato-jugal (*q.j.*) hooks itself into the outer face of the quadrate (*q.*) behind, and overlaps the jugal (*j.*), and the third or jugal process of the maxillary (*mx.*) in front.

Perfecting the palato-maxillary framework in front, we see the vomer (*v.*); at present it is in two halves, which are mixing their osteoblasts under the intertrabecular balk; these moieties, in front, reach to the middle of the maxillo-palatine, and, behind, touch the ascending processes of the palatine.

Outside the quadrate, the squamosal (*sq.*), its proper splint, is walling in the temples, right and left: out of sight, in this view, the nasals, frontals, and parietals are rapidly forming: they will be described in the next stage (Plate VII. and Plate VI., figs. 4, 5, *n.*, *f.*, *p.*). On the lower jaw (Plate VI., fig. 2) four splints are forming, the dentary splenial, supra-angulare, and angulare (*d.sp.*, *s.ag.*, *ag.*): there is no distinct coronoid.

The last parostosis to be described is the first to appear in the development of the skull in the Vertebrata: this is the parasphenoid. To support the huge hypertrophied mass of hyaline cartilage in those selachian Ganoids, the sturgeons (Acipenseridæ), with their imperfectly developed vertebral chain—not fairly differentiated from the cranium, a huge bony splint, is formed, a hard balk under a soft balk for support and strength. This is the first appearance, morphologically speaking, of the parasphenoid.*

Passing to the higher Ganoids and Dipnoi, and thence to the Teleostei, on the one hand, and the Amphibia on the other, we see the parasphenoid becoming dominated by the cranium, and having no sub-vertebral development. All at once, in existing Reptiles, it is fading away, and is quite lost in some lizards (*e.g.*, Trachydosaurus), and in the Chelonia.

It is to the extinct Reptiles, and to the Amphibia, that we must look for anything like what is found in the basis cranii of a bird; and in the former class, not to the Ornithoscelida, with their bird-like hind-quarters, but to those *quasi-Cetaceans*, the Ichthyosaurs.

As a rule, the parasphenoid is like a dagger, with its blade, guard, and handle. In some Anura (*e.g.* Pseudis)† there is no handle to this bone:

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* This is Professor Huxley's term (see "Elem. Comp. Anat.," 1864, p. 170)—a term which, in Morphology, is "a nail in a sure place." This is the bone which, in fishes, was to be divided by Owen's saw! That act of violence was not needed.

† See Philosophical Transactions, 1881, Plates II., X., XI., XII., *pa.s.*

this is what is seen in this embryo of Uria (Plate VI., fig. 1, *pa.s.*). Here the blade is very narrow, being developed later than the guard, which has a right and left centre of ossification in birds.* In the Amphibia, when not in one centre, this element has the point of the blade separate.†

STAGE 2.—*Skull of Embryo of* Uria troile, *two-thirds ripe.*

In this stage (Plate VI., figs. 4–7, and Plate VII.) the *general* has rapidly passed into the *special;* this is in a typical schizorhinal skull, with a sharp face, and having the nasal (*n*) bones split almost up to their frontal or hinder margin. It is now a pattern-form, so to speak, for all those skulls that with this form of the nasals are permanently schizognathous, as in this bird and in a large number of the swimming and wading forms—gulls, grebes, loons, rails, plovers, cranes, &c.; and also for many that become desmognathous, as the ibises, spoon-bills, storks, &c.‡

The endocranium (Plate VI., fig. 4) now shows the normal osseous centres; the oblong basi-occipital (*b.o.*) has formed round the notochord; at a distance from it the ex-occipitals (*e.o.*) are seen as large square plates, enclosing the nerves; and, at a greater distance, the double supra-occipitals form a keystone to the occipital arch. The basisphenoid (*b.s.*) is not, as in Reptiles and Mammals, an independent bone, but, as in certain Urodeles, the parasphenoid (*pa.s.*) grafts itself upon the cartilage at that part: the alisphenoids (Plate VII., *al.s.*) are large cartilaginous wings, with a thick sphenotic outgrowth (*sp.o.*). A large pyriform fenestra (*i.o.f.*) is formed in the high, interorbital wall: above the narrow upper end of this oblique span the presphenoidal region (*p.s.*) is somewhat lipped; these lips are the arrested orbitosphenoids (*o.s.*). Running under the wall, and becoming free at the fore end, the trabecular balk, in its fore half, where it is simply the azygous intertrabecula (Plate VI., fig. 4, *i.tr.*), becomes twisted: it is like a worm struggling to be free; and, indeed, it is becoming fast bound by the enclosing parostoses, that conquer and then destroy it, after building themselves upon it. This rod is only two-thirds as thick as it was in Stage 1 (fig. 1, *p.n.*). Seen laterally, the nasal labyrinth is large, and is quite cartilaginous at present. In all birds the perpendicular ethmoid (*p.e.*) is greatly overgrown, and, in its ossification, thrusts the presphenoid upwards, by meeting and uniting with the basisphenoid: it surrounds all but the hinder and upper part of the great fenestra (*i.o.f.*), and reaches, in front, to the craniofacial hinge (see Stage 3, Plate VI., fig. 8): beyond that part the mesethmoidal wall is differentiated into the septum nasi. The great appearance of complexity in the outer walls of the nasal labyrinth only partially corresponds to what is found within. In front of the orbits the cartilaginous roof, continuous with the wall, is folded over, and a flat plate—"pars plana" or antorbital—is developed as the back wall of the labyrinth: its pointed antero-inferior corner is free, and is the rudiment of the ethmo-palatine bar of a frog, or other Amphibian—Anuran or Urodele. The simple coiling downwards and inwards of the aliethmoids, and the aliseptal coils which form a scroll of less than two horns, the inferior turbinal (Plate VII., *i.tb.*) are like those of the duck or fowl.* The alinasals or valvular folds (*al.n.*) that grow from the fore part of the septum, and in front of it, answering to our "alæ nasi," are long and simple: the external nostril (*e.n.*) which they form is obliquely sub-terminal and reniform.

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* See Philosophical Transactions, 1869, Plate LXXXII., fig. 2, *b.t.*

† Philosophical Transactions, 1881, Plate VIII., fig. 2, *pa.s.*

‡ All such characters as holorhinal and schizorhinal, schizognathous and desmognathous, are valuable and useful in classification, up to a certain point. The exceptions, however, are the most instructive forms, such as the flamingo—an anserine ibis, and psophia—a tinamine crane: these are exceptionally holorhinal among schizorhinal tribes.

The quadrate (*q.*) is now ossifying; a large ectosteal sheath has formed on it; and a flat ectosteal plate (fig. 6, *ar.*) has applied itself to the proximal part of the articulo-meckelian rod (*mk.*) on its inner side; the endosteal centre which completes the articulare is formed afterwards. Answering to the single intertrabecula above, the paired meckelian rods below are longer and slenderer than in the last stage. Like that rod they are strangely twisted, but still more so (as if writhing within the splints); and, had they belonged to the embryo of a captive, or even to that of a less domestic bird, I should have set down this structure to the account of teratology. That view is inadmissible; equally so is that of their having any teleological meaning. We are thus shut up to an ontological hypothesis. The moderate beak of the guillemot, with its horny sheath, has manifestly been modified from a much longer and a dentiferous beak—one like that of Marsh's toothed birds, and not unlike that of the long-faced Pterodactyles.

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* See Philosophical Transactions, 1869, Plate LXXXVI.

If this be the case, we may claim for these embryonic stages an importance equal, in science, to the various adult forms that are being slowly revealed to us in palæontology. As a morphologist "I magnify mine office," and boldly put my stages side by side with my friend O. C. Marsh's adult extinct forms.

This stage and the next are good for showing the normal form of the splint bones or ectocranium of a carinate bird—so unlike those of a Pterodactyle, or of Archæopteryx, and which are a marvellous refinement of such superficial bones as we see in the skull of the existing Ratitæ. Once attained, this type of growth of the outer skull-case is not in any important degree departed from. The figures here given might serve as a generalized diagram for the ectocranium of any one of the existing Carinatæ, which number more than twelve thousand species. If this fact does not prove that all these forms had one father, it at least suggests that they all arose from very similar ancestors.

The very peculiar form of a sauropsidan cranio-facial apparatus was a necessity that arose when the fore-paws were manacled and made useless for prehension in types that were to rival all others in intelligence and skill. We have on one hand, in the beginning, the dull, cold, aquatic quasi-salamandrian ancestor, and, on the other, in these latter days, the lively, hot-blooded songster—that most cunning winged architect. Thus, as the beak has to become the hand, and the neck the arm, the upper face has to be hinged upon the skull proper, and the lower face adapted, in its free mobility, to its elastic upper counterpart.*

In the fixed face of man, or any other mammal, the face and cranium make one undivided skull; the ecto-cranial plates are all firmly tied one to another, to form the solid whole. Here in the bird the extremes meet, of free mobility in the face and palate, and of complete fusion, by loss of all the sutures, in the proper cranial part; but the original form and condition of the splint-bones is quite similar in both regions. These parostoses are extremely thin and elastic in this second stage; but they have already almost a reptilian completeness, and fit one to another in perfect adaptation. The once double premaxillary (*px.*), in a manner truly avian, sends its nasal processes up to the forehead, between the split nasal bones (Plate VI., fig. 5, *n.*), the upper fork of which binds, right and left, upon those splinty processes. Below, in the fore-palate (fig. 4), the premaxillary is sharply split into a dentary and a palatine process on each side; and the great maxillary (*mx.*) wedges itself in between these styloid forks. That bone, becoming a triangular plate, then gives off, externally, a short angular and a long and slender jugal process; and, on its inside, is produced into a larger retral hook, the maxillo-palatine process (*mx.p.*). The jugal arch, externally, is finished by the long and slender jugal and quadrato-jugal (*j.*, *q.j.*), the former overlapping the other two splints, the latter hooking itself into the side of the quadrate (*q.*).

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* For a description of this apparatus, see Bell's "Human Hand," pp. 172–174.

The palatines (*pa.*) are rather broad laths, bent a little outwards, broad behind, and styliform in front; the style runs along the inside of the palatine process of the premaxillary. The pterygoids (*pg.*), like two short pieces of "knee-timber," tie the palatines to the quadrate bones; they are only half the width, and one-third the length, of the latter; and, bending inwards at their middle, abut upon the temporary basi-pterygoids (*b.pg.*). In front, the pterygoid is styloid, and lies upon the palatine; that part undergoes osseous segmentation, and is then the temporary mesopterygoid; it then ankyloses with the palatine: behind, the pterygoid has a cupped facet, which forms a joint with a little ball on the quadrate. Returning to the palatine, we find, on its postero-internal edge a small keel, and outside it, a fossa: this structure is for muscular attachment: above, and in front of those keels, right and left, we see the styloid ascending process. The vomer (*v.*) wedges itself in at that part, and is clipped by these processes; it is a large, long, oblong bone, notched in front, and split in more than its hinder half: it was in two pieces (Plate VI., figs. 1, 2, *v.*).

The maxillo-palatine processes (*mx.p.*) ride over the palatines, and then, hooking themselves backwards in a rounded form, bind against the sides of the double vomer in its fore half.

Above, the lachrymals (Plate VI., fig. 5, Plate VII., *l.*) are seen to be small bony hooks, with just a rudiment of a free supra-orbital process, and a descending part that binds in between the descending arm of the nasal and the antorbital cartilage. The frontals and parietals (*f.*, *p.*,) fail at present to fill in this swollen roof, thus leaving a large fontenelle (*fo.*). The squamosals (*sq.*) are very remarkable, and show us that we have here a bird not cognate with the Anatidæ—the aquatic branch of the bifurcated gallo-anserine types—but a relation of the gulls and their allies. This is at present inexplicable; for, in the Cretaceous epoch, as we have seen,* the divers and the gulls were as far apart as they are at this day. In the swan (Plate IV., *sq.*) and in the fowl (*op. cit.*, Plate LXXXIV., fig. 8, *sq.*) the squamosal is a broad shield-shaped plate; but here, in this diver, it is long and falciform (Plate VII., *sq.*)—quite like that of the gull. This, we shall soon show, is not the only thing in which these two kinds of birds agree. Nevertheless, if Professor Huxley's Cecomorphæ is to contain both these types, it must also be strong enough to bind together Marsh's Hesperornis and his Ichthyornis.

The parasphenoid on the base (Plate VI., fig. 4, *pa.s.*) runs over the vomer as a grooved and styloid bar, the trabecular balk lying in the groove (see next stage, fig. 8, *pa.s.*); it has made a floor to the pituitary space, has ossified the basisphenoidal region, has formed the anterior tympanic recesses, and has grown into a pair of basi-temporal wings (*b.t.*) that support the lagenæ (*au.*).

Below, the four mandibular splints (fig. 6, *d.*, *sp.*, *s.ag.*, *ag.*) are elastic "withs" that are binding the struggling meckelian rods, which they will soon overcome (see next stage, fig. 8).

The hyoid arch in this stage is composed of the columella (*co.*) above and the two arches below; the infrastapedeal at about this time, acquires a small addition in the form of an arrested epi-hyal tract; this, in the adult, is the small tape of cartilage that lies upon the basi-temporal plate, at the lower edge of the membrana tympani. The rest of the hyoid (fig. 7) has not altered much, except in size, since the last stage (fig. 3); yet the cerato-hyals (*c.hy.*) are becoming fused to form a basal piece in front.

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* Transactions, Linnean Society, New Series, Zoology, vol. i., Plates XXVI.-XXVII.

STAGE 3.—*Skull of Embryo of* Uria troile, *nearly Ripe.*

A vertically longitudinal section of the skull, at this stage (Plate VI., fig. 8), shows that the hind brain only lies in that part of the floor which is actually basal, and that this is only one-sixth of the length of the head. But the oblique basi-cranial line (from the occipital foramen to the fore end of the frontal cavity for the hemispheres) is half that length; the brain is a curved bulb, with its narrow part at the top and in front. The sudden lessening of the bulb at the middle of the hemispheres removes the necessity for any special orbito-sphenoids beneath it; but it causes a remarkable thrust, outwards, of the huge alisphenoids (*als.*), which are almost transversely placed, and form the back wall of the large orbits, which closely approximate right and left of the interorbital wall. This tilting of the brain is combined also with that of the auditory capsules, for these lie back so as to form an acute angle with the basis cranii. But the shortness of the hinder cranial floor is nothing new; where that floor is long, as in Selachii and Amphibia, the fore half is not axial; the axis, or notochord, always ends behind the pituitary involution. Here, in the bird, it only runs up into the post-clinoid wall (*p.cl.*), and then retreats,* so as to become the axis of the only part that can be shown to be homologous with a vertebral centrum or with centra. In the chick † the notochord becomes sub-moniliform; and, in the last of the three enlargements, the basi-occipital (*b.o.*) arises. Thus, the specialization of the neural axis is correlated with a specialization of the skeletal part that contains it; ‡ in Selachians this moniliform condition of the cranial end of the notochord is very remarkable, and shows how indefinite the boundary is between the cranium and the spine in those types.*

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* See Fowl's Skull, Plate LXXXI., figs. 2–4, *nc.*

† See Fowl's Skull, Plate LXXXII., fig. 3, *nc.*

‡ Transactions, Zoological Society, vol. x., Plates XXXV. and LX., *nc.*

Whatever may be the nature of the *pro-chordal* tracts of the primitive cranium, they are responsible for a very large part of the cephalic endoskeleton; in this case for five-sixths of its length. The optic nerves (ii.) pass directly over the low hindpart of the great partition wall, at a short distance in front of the foramen ovale (v.), which is a large round notch, at present, between the auditory capsule and the wide alisphenoid. Between those two nerves the sixth, fourth, and third nerves escape into the orbit, whilst the seventh and eighth (vii., viii.) have their passages in the fundus of a pit in the auditory capsule—the "meatus auditorius internus." Between the capsule and the occipital arch the glossopharyngeal and vagus (x.) escape, and the hypoglossal (xii.) through the ex-occipital. Rising almost vertically, with the alisphenoid right and left of it, the wall at its oblique postero-superior corner is slightly two-lipped; these lips are the feeble orbito-sphenoid (*o.s.*). In front of this part the first nerve (i.) runs right and left of the wall-top, grooving it. The olfactory crus is simple, and supplies a very simple nasal labyrinth. In front of the bony sella turcica (*py.*) the great trabecular balk is seen to form a thick base to the wall. Above in the olfactory region the aliethmoidal laminæ grow out from its top; the partition and these alæ chondrify together, and the nasal capsule has lost its independence in these high types. A little further forwards the alæ are called aliseptal (Plate VII., *al.sp.*), and give rise to the coiled inferior turbinal; still further forwards they are called the alinasals (*al.n.*), being the valvular folds that surround the external nostril (*e.n.*). The great partition, once a continuous tract as in the adult Ratitæ, has now a large, oblique, pyriform fenestra between the eyes, and, in front of the true olfactory region, a large semi-circular notch (Plate VI., fig. 8, *c.f.c.*). Behind that notch the wall is triple; in front of it it is single, for the trabeculæ cranii only reach thus far, and the rest is formed of the azygous intertrabecula. Here we see Nature dissecting her own work! The parts that had become fused together are separating once more. Not only is the intertrabecula separated from the ascending wall under this great cranio-facial notch or cleft, but it is, also, under the septum nasi (*s.n.*). That fore part of the general wall is of slight vertical extent in front, and thus the two nostrils communicate—a common thing in birds thus to have their nostrils open through. The intertrabecula, having served its purpose, is now ready to vanish away; in the old bird it has been absorbed—all but the part which helped the paired trabeculæ to form that part of the balk which is behind the hinge-notch. That notch has a thick, but lessening, isthmus above it; in front of that, the orbito-nasal branch of the fifth nerve supplies the part; behind it, the olfactory nerve is distributed to the slightly folded mucous membrane. Behind the notch, a little higher, there is a bony plate as large as that notch; this is the perpendicular ethmoid, or mesethmoid process. The centre of the gently-swelling alisphenoid (*al.s.*) is ossified; the pituitary region has its borrowed basisphenoidal bony tract (*b.s.*); the occipital arch is now in four centres—the supraoccipital (*s.o.*), once double; the exoccipital (*e.o.*); and the oblong basioccipital (*b.o.*). In front of the exoccipitals a small lanceolate opisthotic (*o.p.*) is seen; and a large, squarish bone—the prootic (*pro.*)—is formed round the holes for the facial and auditory nerves (vii., viii.). Between the side of the supraoccipital and the large arch of the anterior semicircular canal (*a.s.c.*) there is a semicircular space fitted only with membrane; this is the lateral occipital fontanelle which characterizes the skull in so many water and wading birds, not excepting the Anatidæ, which are so unrelated to the rest.*

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* See Dr. Emil Rosenberg's excellent memoir, "Untersuchungen über die Occipitalregion des Cranium und den proximalen Theil der Wirbelsäule einiger Selachier." Dorpat, 1884.

The articular (*ar.*) is enlarging, but I do not yet see the separate endosteal centre in the articular enlargement of the mandible; the outer centre appears some weeks before the inner; it is some years before the latter appears in the green turtle (*Chelone viridis*); and its ectosteal articulare might easily be mistaken for a mere parosteal splint by a young and incautious morphologist.

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* The final purpose of these windows in the back of the head, in these birds, which are made and then filled-up, as though they had been taxed, is not possible to conceive. The middle occipital fontanelle, in owls and pigeons, is a mere economy of stuff.

The ectocranium at this stage is seen as an admirable supplemental growth of bony scales over and around the primordial skull and face. The imbrication of these "natural selections" from the inner face of ancient ganoid scales, notwithstanding the extreme degree of specialization that all these parts have undergone, is still as visible as that of the armour of any ancient type of vertebrate. And yet, almost all these superficial bones have their names from human anatomy, and a beginner can see the maxillary, inter-maxillaries, nasals, frontals, parietals, squamosals, vomer, &c. (Plate VI., fig. 8, *mx.*, *px.*, *n.*, *f.*, *p.*, *sq.*, *v.*).

Archaic parts, however, not seen in our own skull, are seen here, namely, the rostral basitemporal parts of the ancient parasphenoid (*pa.s.*, *b.t.*); and on the mandible all the reptilian splints except the coronoid (which also is present in the arboreal birds, but not in these and many other Precoces). But the dentary (*d.*), the splenial (*sp.*), the supra-angulare (*s. ag.*), and the angulare (*ag.*) are well developed here, but little altered from what is seen in ganoid fishes.

From the time of hatching to the first birthday of the bird, in one year nearly every trace of the old landmarks are removed; only in the specifically ornithic jaws and palate are the elements at all kept apart. About half of these are required in this most mobile apparatus.

At this point, my work is supplemented by Dr. R. W. Shufeldt's valuable Papers, especially in that which treats of the skull of the adult guillemot.* In one or two points as to the ossification seen in the skull of the adult Alcidæ, my valued fellow-worker has not quite caught my meaning in certain of my memoirs on this subject.

In his earlier Paper on Alca in which the skeleton of *Alca torda* is described,† Dr. Shufeldt mentions a little bone attached to the lachrymal, and which he supposes is the one called by me "os uncinatum" in my Paper in the Encyclopædia Britannica, vol. 9, art. Birds, p. 714. The bone referred to is, however, merely a limited ossification which takes place in the hind part of the coiled inferior turbinal. This bone in my specimens is an elegant open ring, the bony deposit having affected the whole coil to a short extent; it is formed in front of the pars plana, where these two parts are confluent.* But the true remnant of the os uncinatum is formed in the intero-external angle of the pars plana (Plate VII., *p.p.*, Plate VI., fig. 4, *p.p.*), which is the homologue of the ethmo-palatine of the frog.†

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* Jour. of Anat. and Phys., vol. xxiii. (vol. iii. n. s.), pp. 166–171, Plate VII.

† *Ibid.*, vol. xxiii., p. 8, Plate I.

Besides the special middle turbinal centre which ossifies nearly all the pars plana of these birds, there is formed in the adult a small milioline bone in the angle just where the lachrymal ends below. There are two such nuclei on the right side, some on the left in one of my specimens of the skull of *Uria troile*, and one in the rest of my Alcidæ, namely, *Alca torda* and *Fratercula arctum*. In gulls of the first year this angle remains unossified; but in old specimens it becomes a distinct os uncinatum, almost as well developed as in the albatross. In an old *Larus argentatus* it is triangular, and the lower and longer side which is notched, is two millims. in extent. In an old laughing-gull (*Gavia ridibunda*) it is a wedge-shaped bone, 1·75 millims. long, and 1 millim. wide above. The ossified ends of the inferior turbinals are very distinct and elegant in all my specimens of Alcidæ; and they have the same development in *Alca impennis*, as my friend Frederic A. Lucas has shown me. In a letter to me, dated January 22nd, 1888, he gives some descriptions and careful drawings of these parts, and also of another important and much larger osseous centre. This larger bone is the ossification of the thick isthmus of cartilage shown in my third stage in *Uria troile* (Plate 6, fig. 8, *c.f.c.*). That isthmus remains, for the segmentation of the wall is not perfect, and the septumnasi (*s.n.*) in front of it is arrested. This fore-wall is feeble in the adult of these Alcidæ. This part is broad and carinate; the perpendicular ethmoid (*p.e.*) stops short at the point it has reached antero-superiorly in my third stage; and the roof and keel in front of it is ossified as a separate thick wedge of bone. This is seen in *Alca impennis*, *A. torda*, *Uria troile*, and *Fratercula arctum*, and is mentioned by Dr. Shufeldt in his description of the skull of Uria (*op. cit.*, p. 170) as existing both in that bird and in Alca. In old species of *Uria troile* I find it 9 millims. wide behind, and 9 millims. long; and in front of these is another bone like it, but only one-fourth the size. In an old *Gavia ridibunda* there is a similar septal bone behind; then a small nucleus; in front, the whole top of the septumnasi is ossified, and has coalesced with the nasal processes of the premaxillaries. This septal ossification, generally in one piece, is found in many of the Grallæ and Palmipeds, to say nothing of arboreal types. I find the main or hinder piece in *Podiceps minor*, *Rallus aquaticus*, *Porphyrio poliocephalus*, *Ardea cinerea*, and in Nycticorax.

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* See Fowl's Skull, Plate 86, figs. 6 and 8, pp. 1–16.

† See my Paper on "Remnants and Vestiges," Proc. Roy. Soc., vol. 43, Febr. 23, 1888, pp. 400, 401.

The basi-pterygoids are absorbed in the adult;* but the pterygoids retain a little ingrowth towards the place where they existed in the embryo. For the rest the reader is referred to Shufeldt's excellent figures and descriptions.

I have purposely referred to the structure of other types of water-birds and of their grallatorial relatives. Guided by the skull alone, we might tie into one taxonomic bundle many a family of these birds: that is a clear fact, and most important in ontological research. But it is a misleading thing to do this in ornithology;—a gull is one thing, a guillemot is another, and a plover is diverse from both. Let us keep our evolutional speculations apart from our taxonomic work: "there is no need of such varieties" in that field of Science.

The Vertebral Chain and Ribs in Uria troile.

1st, 2nd, and 3rd Stages; and 4th, or *Adult.*

It will be convenient to describe these stages together for the sake of the mutual light shed by them. The vertebral formula in this type is as follows:—

> C. 15 (two or three ribs free); D. 7; D. S. 2 (second rib imperfect); L. S. 3; S. 4; U. S. 5 (riblet on first of these fused); Cd. 10 + 3: Total 49.

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* See in *Alca torda*, Shufeldt, *op. cit.*, Plate I.

In the first stage (Plate VIII., fig. 1) there are only twelve vertebræ between the hip-plates instead of fourteen: this is the ornithoscelidan stage. In the second stage there are three distally articulated ribs on the left side, at the end of the cervical region (Plate VII., *c.r.*): the first of these becomes fused in the adult.

It is worthy of remark that these birds, which feed on "small fishes and crustacea,"* should have a very strong neck with short vertebræ that have strongly marked processes, whilst the heron, which, as a rule, deals with large prey, should have long, smooth, slender cervical vertebræ. I suppose it is due to the more hurried manner in which they feed. The meditative heron, when the necessity is laid upon him, suddenly—swift as an arrow—seizes his prey. As compared with the Anatidæ of the same size, the guillemot has fewer cervicals, and each bone is shorter; more dorsals—seven instead of five; fewer dorso-sacrals and uro-sacrals; and a rather longer, but feebler, caudal series. The spines, both upper and under, are strong; the riblets are well developed, but do not exist on the atlas. On the left side the last three, on the right the last two, are free. In the second stage (Plate VII.), in the pre-sacrals, ossification has taken place in the centra, neural arches, and riblets; these latter are losing their distinctness. The odontoid element, already united with the axis, the fore part of the centrum of that joint, and the base of the atlas, are not yet ossified—one centrum and two intercentra. Below, where the ribs are articulated, the cervicals become rapidly approximated to the dorsals; the spines become square and crowded; below, the spaces are bifurcated and dilated, right and left. In the general sacrum, and in the caudal region, the centra are acquiring an osseous deposit in the sheath of the notochord, but not as yet the neural arches.

In Stage 1 the vertebræ are unossified; in the pre-sacral region the notochord, which had shown contractions at the joints, had become largest there, and also was constricted so as to have two new swellings inside the cartilaginous centrum. Behind the dorsal region (Plate VIII., fig. 1, *nc.*) only two moniliform swellings are seen in each centrum, and these are lost in the caudal region; yet there the notochord has the amphibian character of being largest at the intercentral spaces.*

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* Macgillivray, "Manual of Ornithology," 1842, p. 213.

Hence, this vertebral chain has evidently, like the rest of the organism, been subjected to some dominating force that has fashioned it anew for some further and higher ends in life, so that some unsightly creature, not perhaps dissimilar to Siebold's gigantic salamander, or the eel-like *Siren lacertina*, has been "clothed upon" not only with a warm, soft, feathery and downy vestment, but has had its whole structure metamorphosed into this "rich and strange" type. Nearly half a hundred links have been developed in this cunningly wrought chain, where, perhaps, a hundred did exist in the low quasi-larval ancestor. It is passing strange that a *blind force* should produce such "new things in the earth."

The stunted condition of these post-dorsal vertebræ, the fore half becoming fused and the hind half arrested, is in harmony with the rest of the structure of this Pygopod; nevertheless, had it been necessary, a moderate amount of elongation would have made the eighteen vertebræ that are behind the true sacrals into the tail of a Saururous type as long as the rest of the spine. The last four imperfect segments formed round the notochord become the uropygial joint; the nine in front of that keep distinct; their transverse processes (diapophyses) gradually decrease to the end.

In this first stage the ribs on the first dorso-sacral are developed—are almost complete below; but on the second they are in three pieces, the proximal (Plate VIII., fig. 1, *s.r.*) being a very small bar—simply a rudiment of the capitulum and tuberculum. On the first uro-sacral there is an attempt at the formation of a distinct rib bar. Hence, this part of the axis is seen to be less perfectly developed than in the Anatidæ.

Before hatching, in my third stage (Plate VIII., figs. 2, 3), the whole of the general sacral series is enclosed between the ilia; and the centra, but not the neural arches, except in the first dorso-sacral, are ossifying. These bony patches, formed, at first, round the notochord, are transversely oval: the widest are in the swollen proper sacral region. These tracts are formed

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* See Proceedings, Royal Society, 1888, p. 466; and Foster and Balfour's "Elements of Embryology, 1874," p. 157.

as far back as to the last four imperfect segments. Under the largest of these, and under all the rest of the free caudals, there is, at the fore edge of each centrum, a small milioline intercentrum; above (fig. 3), four vertebræ have a spine, that on the fourth being the smallest. The last lumbo-sacral and those of the four proper sacrals are mere round belts; then a small tubercular spine reappears, and is hardly lost on the last of the four uropygial segments. That the cervicals in the adult are short is seen by the following measurements:—The centrum of the eighth, or longest of this chain, is 11 millims. long, the whole length of the vertebræ, with its oblique processes, being 16 millims., and the width over the prezygapophysis 14 millims. The spines are well developed; the four next behind the atlas have upper and lower spines; the tenth has a large lower spine; then this decreases, and there are three such outgrowths on the fourteenth. On the fifteenth, or last cervical, and on the first two dorsals, the lower spine is double, and dilated transversely, as in the loon (Colymbus), and another fish-eating bird not related, the kingfisher (*Alcedo ispida*). The other five dorsals—the first dorso-sacrals—have long simple spines, pedate below, sloping from before .backwards; these spurs are like those of the grebes (Podiceps), but are not so long. In this point the guillemot is intermediate between the loon and the grebe, as Hesperornis is in its general structure.

The upper spine reappears in the last three cervicals. Thus, the last of these, the seven dorsals and the two dorso-sacrals, form a gently arched series of square spines, closely fitting—that is, with only a small tract of elastic ligament between them, and tied together by fine bony tendons. The dorsals, one with another, and the last of these with the first dorso-sacral, are united by opisthocœlous joints, that have paired overlapping processes, such as I have described in the oil bird.* All the cervicals, even the last or fifth in its junction with the first dorsal, are heterocœlous, or cylindroidal. The caudals are feebly amphicœlous, and have no joint cavity.

In the guillemot the atlas has no rib bar enclosing the vertebral artery, as in the duck and its congeners. It has one, however, on the axis, which is not present in birds generally; these riblets are developed into a long style on the 3rd, 4th, and 5th, and these become short, and the retral part is lost. The free rib on the 14th is 8 millims. long; that on the 15th is almost as long as that on the first dorsal, and it has an ossified uncinate cartilage (see Plate VII.); these parts are long, and are present also on all the seven dorsals; thus there are eight pairs of them; they do not become fused with the ribs. The ribs are extremely long, slender, and sinuous in form, and are articulated to equally delicate sternal ribs at an acute angle. The first forms, when at rest, a right angle merely; this is seen in an exaggerated form in the embryo (Plate VII.). Of course they are somewhat opened out in inspiration. The last dorsal rib in *Uria troile* is 95 millims. long, its sternal piece 81·5 millims., a little more than half the length of the same parts in *Alca impennis.*[*] The cinctures formed by the first dorso-sacral rib just fall short below; that of the second dorso-sacral is in three pieces on each side. Above, a delicate bridge of bone is ankylosed to the vertebra at both ends; below a distal piece appears, 40 millims. long, attached to a sternal piece, 50 millims. long; the average breadth of these needles of bone is ·75 millims. Sitting up, in full dress, these birds have a bulky look; but they are much more compressed than the duck or the penguin; and their trunk is not only very long for a bird, but also very deep.

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* Steatornis, Proceedings Zoological Society, 1889, Plate XVIII., p. 174.

In the loon (*Colymbus septentrionalis*), and in the great diver (*C. glacialis*), as also in the grebes (Podiceps), the body is very flat or depressed, strikingly so; compare *Alca impennis* (*op. cit.*), and Brandt's figures of the skeleton of the loon (*Eudyptes* (*Colymbus*) *septentrionalis*), and of *Podiceps auritus.*[†] Besides, in these latter birds the ribs are much shorter and stronger than in the Alcidæ.

Altogether, in comparing these water-birds, each family seems to me to be isolated, and they are probably much less nearly related to each other than they seem to be, the similar adaptive modifications giving them a misleading isomorphism.

In my second stage (Plate VII.) the ribs are acquiring a long ectosteal sheath, the sternal ribs (*s.r.*) are not yet ossified; their ossification takes place in the same manner as in the vertebral ribs.

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[*] Owen, Transactions Zoological Society, vol. v., Plate LI.

[†] "Zur Osteologie der Vögel," 1837, Plates XVI. and XIV.

It is evident that sometimes the last cervical rib may join the sternum by a sternal piece, although as a rule in *Uria troile*, *Alca impennis*, and *Alca torda*, there are only seven pairs of sternal ribs. This additional sternal exists in my third stage,* although there are only seven in the first stage (*ibid.*, fig. 10), and in the second stage also (Plate VII. of this memoir).

Also, in the same figure of the thorax of the third stage, the uncinate cartilages (*c.a.*) are seen to have an adze-shaped dilatation above, when they are fully formed. Even this undergoes change, and the enlargement is much less evident in the adult. With regard to the number of perfect cinctures in the thorax in all Dr. Shufeldt's exquisite figures,† there is only one with eight perfect sternal ribs, and this is on both sides (Plate III., fig. 18, and Plate IV., fig. 20, p. 23). My specimen has only seven on each side; and some of the small forms of Alcidæ figured by Dr. Shufeldt (*op. cit.*, Part III., pp. 400–558) are shown as having only six.

The Sternum and Shoulder-girdle of Uria troile, *Embryos and Adult.*

My dissection and drawings of the sternum of the first stage made long ago (*op. cit.*, Plate XVII., figs. 10, 11) show that the metasternum is small at first; at that time it is no longer than the proper costal tract; in the adult it is three times as long (see Shufeldt). Why in these birds, which have a tendency to abort the wing into a mere paddle, and in Tinamous which have short wings that they have scarcely the sense to use, the metasternum should be so extremely long, whilst in gulls, cormorants, the tropic bird (Phaëton), and in the frigate bird (Tachypetes), it should be so short, is to me, not at present engaged in myology, an anomalous fact. The mechanism of flight in all these birds should be studied in reference to this; for the metasternum is, like the sternal keel, a thoroughly avian structure. In Mammals it is a very feeble structure; and in its earlier appearance in Reptiles (Stellio, Crocodilus, *op. cit.*, Plate XI., figs. 1, 2, 7, and 8) it is

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* See "Shoulder-girdle and Sternum," Plate XVII., fig. 14.

† Jour. of Anat. and Phys., vol. xxiii.

scarcely stronger than a rib. The common granular plate in which the rib, at first, ends below, soon chondrifies, and then the right and left moieties meet, unite together, form a keel, and become segmented from the lower costal segments, or sternal ribs (*op. cit.*, Plate XV., fig. 1).

In my first stage all this is complete, the structural relations are perfect; but the relative proportion of the regions undergoes much after-change.

In the second stage (Plate VII.) the rapidly growing embryo has its sternum quite similar to that of the adult, and the metasternum is already twice as long as the costal edge. The pre-costal process (*p.c.p.*) has room on it for two more sternal ribs, which might have grown down from the neck. The rostrum, a special avian outgrowth,* and not a further sternal rudiment, is already formed as a semicircular figure-head, separated from the sharply-produced keel (*st.k.*) by an almost regular semicircular notch. From that point to the flat, thin, keelless hind-part of the middle metasternal process, the outline of the keel forms a large part of a quadrant. This convexity of outline is also seen in the body of the sternum, which at this time bellies downwards, the thoracico-abdominal cavity being pregnant with the copious viscera, and a huge mass of still unused food-yolk. The lateral metasternals (*m.st.*) are separated by a round notch from the middle plate, and are only half as long as its keelless part, behind the fore end of the notch.

In the third stage (*op. cit.*, Plate XVII., fig. 14) the sternum is rapidly approaching the adult form, which is well illustrated in Miss Beatrice Lindsay's Paper (*op. cit.*, p. 690, fig. 1), and still better in Dr. Shufeldt's 4th part (p. 538, fig. 1, and p. 546, fig. 4). The sternum straightens out very much, and the line of junction of the keel and body becomes sinuous, for it rises in the middle of the metasternum. The keel projects its angle in front of the large deep rostrum, and ends behind in a thickened edge, 3 millims. wide; beyond this about 7 or 8 millims. of the rounded end is unossified. The rostrum comes up well between the coracoid grooves. The whole bone is very evenly oblong; it measures 37 millims. across the tips of the pre-costal processes, and also across the outer metasternal processes, and only 31 millims. behind the last sternal rib. The whole median length is 123 millims.—nearly four times the average width; and the keel is 128 millims. long, measured in a straight line above its gently curved lower limbate edge: its greatest depth is 30 millims. The depth of the notches in the metasternum varies in individuals; in my specimen of an adult they reach half-way to the last sternal rib, and the lateral bars are 20 millims. long and 4 millims. wide. The gently descending series of the seven transverse costal condyles look equally outwards and upwards; thus the costal cinctures swell out above the sternum.

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* Lindsay, Proceedings Zoological Society, 1865, p. 707.

I have noted down this great length and narrowness in the guillemot, both for comparison with the short-breasted gulls,[*] which come so near the Limicolæ in this respect,[†] and also with the loons.[‡] In the gulls the sternum is both narrow and short; in the loons it is as long, or nearly so, as in the Alcidæ, but much wider. These long sterna had their counterpart in an arrested condition due to the abortion of the wings in the extinct Hesperornis.[§] In that bird the sternum, and also the furcula, are almost exactly like those of my third stage of the guillemot.[||]

Even the skull itself is of less value to the ornithologist than the sternum; it will be seen at once that this statement is somewhat remarkable as coming from one so partial to the skull. And yet, notwithstanding this, the Alcidæ, in several important respects, come nearer to the Laridæ than to the other divers (Urinator, Eudyptes, or Colymbus), for these latter forms, with their quasi-ancestor Hesperornis, and the grebes, have all their pre-sacrals cylindroidal.[¶]

The ossification of the sternum in the Alcidæ is by a very generalized sort of endostosis, the lophosternum having a very short independence of the pleurostea. The shoulder-girdle of the guillemot[*] has a falciform scapula (*sc.*) nearly twice as long as the coracoid (*cr.*). In the first stage (*op. cit.*) the axes of these two bars are coincident; they are ossifying separately, but are only half free from each other at the shoulder-joint. On the fore part of the head of the coracoid there is a small continuous remnant of the precoracoid, which becomes the clavicular process. In the third stage (*op. cit.*) there is a separate nucleus of cartilage—an external precoracoidal remnant—which becomes part of the ramus of the furcula, after undergoing endostosis; and it forms a shelf, on which the large forwardly-curved head of the coracoid rests; that is a flat synovial joint. This structure can be seen even on the inner aspect.[†] The shaft of the coracoid is moderately slender, and the epicoracoid below has a dilated hook at its hinder angle.[‡] The clavicular rami are largely curved forwards above, and the whole from a side view, with the crescentic interclavicle, forms a rough semicircle; but the rami are not so evenly curved as in the loons,[§] which have also a smaller interclavicle. In the loon, in the first stage of Uria,[‖] and in Hesperornis,[¶] each ramus is much dilated above; and this dilatation is formed in a mass of granular tissue, which is almost cartilaginous, and belongs to the acromial or meso-scapular region. The rami of the furcula, like the little bone at their junction (the interclavicle), are parostoses. This median part was not seen by Marsh in Hesperornis.[**]

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[*] Shufeldt, Part i., Plate IV., fig. 2.

[†] *Ibid.*, figs. 22 and 23.

[‡] Shufeldt, Part ii., Plate VIII., fig. 7; and Brandt, *op. cit.*, Plate XVI.

[§] Marsh, *op. cit.*, Plate VII.

[||] Shoulder-girdle and Sternum, Plate XVII., figs. 10, 11, and 13.

[¶] The nomenclature of these birds is very confusing. E. Nitzsch (Pterylography, Ray Soc., 1867, p. 152, Plate X., figs. 10, 11, and 12) calls the grebes Colymbus, and the loons Eudyptes; whilst Macgillivray (Manual, 1842, pp. 200–206) calls the grebes Podiceps, and the loons

Anyone who will compare together the figures given in the thirteenth Plate of my work on these parts will see at a glance that the reptile has the raw materials out of which the bird's shoulder-girdle might have been made.

Colymbus; whilst Brandt (*op. cit.*) calls the loons Eudyptes, and the grebes Podiceps. To mend the matter, the best and latest authorities, the ornithologists of the American Union (The Code of Nomenclature and Check-List of North American Birds: New York, 1886), have for the grebes the generic terms Æchmophorus, Colymbus, and Podilymbus; and for the loons Urinator (pp. 73–76).

[*] *Op. cit.*, Plate XVII., figs. 10–4; and Plate VII. of the present Paper.

[†] Shufeldt, *op. cit.*, Part iii., p. 556, fig. 8.

[‡] *Ibid.*

[§] Brandt, Plate XVI.; and Shufeldt, Part ii., Plate IX., figs. 2 and 13.

[‖] *Op. cit.*, Plate XVII., fig. 13.

[¶] Marsh, *op. cit.*, Plate VI., fig. 3.

[**] *Op. cit.*, Plate VII., fig. 8.

The Wings of Alca torda *and* Uria troile *in Embryos and the Adult.*

The wing in *Alca torda* one-third ripe, and therefore answering to my first stage in the guillemot, is considerably advanced in growth (Plate IX., figs. 1 and 2); it answers very nearly to my third stage in the duck (Plate I., fig. 6). The main parts are already well formed, and the larger rods have their ectosteal sheath; but the parts that form the strangely modified carpus are still cartilaginous.

The radiale and ulnare (*re.*, *ue.*) are large and normal, and the distal carpals (*d.c.*^{1} *d.c.*^{2} *d.c.*^{3}) are well formed. The first of these is on the inner side (fig. 2, *dc.*^{1}); it is ear-shaped, and strives to reach its own short metacarpal (*m.c.*^{1}) which is fused with the great crescentic second metacarpal (*m.c.*^{2}), as also is the oblong third distal carpal (*d.c.*^{3}). The great second metacarpal is four times as long as the first, and one-fourth longer than the third (*m.c.*^{3}), which is also very slender. The proximal phalanx of the large index (*dg.*^{2}) is beginning to ossify; all the rest are cartilaginous. The two phalanges of the pollex are equal in size to the two distal ones of the index; the one distal or undivided phalanx of the third digit (*dg.*^{3}) is two-thirds the length of the proximal phalanx of the pollex.

In the second stage *Uria troile* (Plate VII. and Plate VIII., figs. 7 and 8) shows some new parts besides increase in size and development of two new bony sheaths, one in the proximal phalanx of the pollex, and another in the middle phalanx of the index. The distal phalanx of the pollex is now very small, and the claw is dying out; and that of the index is almost fused with the middle piece. The displaced and greatly masked first distal carpal (*d.c.*^{1}) has its base, on the ulnar side, dilated and fused with the parts on which it lies: a little beyond it, inside the head of the third metacarpal (*m.c.*^{3}) there is an oval segment of cartilage half the size of the first distal carpal; that is the remnant of the fourth metacarpal (*m.c.*^{4}). On the ulnar, or hinder, side of the large proximal phalanx of the index—between it and the lessened phalanx of the third digit (*dg.*^{3})—there is a new lanceolate cartilage, which is already receiving bony deposit from the ectosteal sheath of the large primary bar to which it is attached; this is a proximal secondary phalanx ($dg.^{2'}$). Above, in the outer or extensor face of the manus (Plate VIII., fig. 8, $mc.^{2'}$), there is a semi-lanceolate tract of cartilage outside the ectosteal sheath of the great second metacarpal ($m.c.^{2}$)—a secondary metacarpal; a weak fork of the index. That attempt at bifurcation of the great second ray of the hand is connected by a distinct but slender isthmus with a fork of the great second distal carpal ($d.c.^{2}$). I can find no teleological reasons for these multiplications or forkings of the contracted and aborted manus of the bird.*

In *Alca torda*, also, the second stage (Plate IX., figs. 3, 4) is illustrated. It shows the same parts as the similar embryo of the guillemot. In this embryo the pollex and index have both kept their distal joint distinct; and in the third digit there is a very small grain of cartilage distinct from the proximal part. The first distal carpal and the fourth metacarpal (figs. 3, $d.c.^{1}$, $m.c.^{4}$) are clearly seen; and, on the outer side, the second distal carpal has sent on a styloid fork, which is connected by a membranous isthmus with the secondary second metacarpal (fig. 4, $m.c.^{2'}$).

In both *Uria troile* and *Alca torda*, the third stage, or almost ripe embryos, show a still further growth of the wing. In Uria (Plate IX., fig. 7) the changes from Stage 2 are merely those of growth. In Alca (Plate IX., figs. 5, 6) I have shown the parts on a larger scale; in these we see that the cartilages are becoming vascular, ready for ossification. The great proximal carpals (*re.*, *ue.*) show by their lobes that they represent more than one normal nucleus; and the distal carpals ($d.c.^{1-3}$) are still sufficiently distinct to illustrate their peculiar forms and relations. On the fore edge of the first metacarpal ($m.c.^{1}$) there is a suspicion of a pre-pollex in the peculiar form of the trochanter. The ventrally displaced first distal carpal (*d.c.*^{1}) is attached by a large base to the second and third metacarpals; and, on the postero-internal face of the latter, the fourth metacarpal (*mc.*^{4}) is clearly seen as an oval milioline nucleus of solid cartilage. But these unhatched Alcidæ are not all that is needed for the interpretation of the adult wing. Happily, however, through the kindness of Frederic A. Lucas, Esq., of Washington, I am able to show the structure of the wing in a half-grown bird—the smallest of the family, namely, *Ciceronia pusilla.*[*]

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* If anyone studying these parts does not see in them a repetition of what occurs in the fore paddle of an Ichthyosaurus; and if, looking at both, he is not irresistibly carried into ontological speculation, there must be some weak spot in his mind. All minds are not so timid: whilst writing the above I have received a very valuable Paper on this subject, by M. Alfred Tschan ("Recherches sur l'Extrémité Antérieure des Oiseaux et des Reptiles." Geneva, 1889). Both as to personal research and as to Bibliography, this Paper comes to me very opportunely, and I am grateful for it. I cannot, however, quite see with M. Tschan as to the manus of birds; he would make the normal third ray to be the fourth digit—the third, in that case, being my intercalary post-index (p. 59).

In this *relatively* large bird of the first summer I found an explanation of what is remarkable in the pollex (in many cases it is seen in the index also) of water-birds—Alcidæ, Procellariidæ, and Phalacrocoracidæ.

In the long manus of the smallest auk (Plate VIII., figs. 9–13) the ossifications are, in this immature bird, nearly all distinct, and thus very instructive. The distal carpals (figs. 9 and 12, *d.c.*^{1}, *d.c.*^{2}, *d.c.*^{3}) are bounded by sutural lines that are just becoming obliterated, and the three metacarpals are not yet fused. There is no appearance of a distal joint in the third digit (*dg.*^{3}), but those of the pollex and index (*dg.*^{1}, *dg.*^{2}) are ossifying as a separate endosteal patch. The latter have become fused with the middle phalanx, as in *Uria troile* (fig. 7); the last phalanx in the pollex keeps its distinctness, as in the large bird. The semi-lanceolate secondary second metacarpal (*m.c.* $^{2\prime}$) is getting some bony deposit from the main shaft; that of the proximal phalanx is completely fused with the main piece, and is largely ossified. Another very distinct segment of cartilage has appeared in the ulnar side of the proximal joint of the pollex, near its distal end (*dg.* ^{1}). This is a perfectly distinct semi-oval cartilage, which is ossifying from its own proper endosteal centre, just as the secondary metacarpal of the index does in passerine birds, when it is most perfectly developed. The ungual phalanx of the pollex has a delicate claw upon it. This post-pollex is accompanied with a post-index in these Alcidæ and some other Palmipeds; for, in the adult *Uria troile*, *Alca torda*, and *Fratercula indica*, the same flange is seen in both of those digits (see in *Uria troile*, Plate IX., figs. 11, *dg.* 1^1, and fig. 12, *dg.* 2^1).

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[*] *Simorhynchus pusillus* (see Check-List of North American Birds, p. 79).

All the secondary parts, or feeble forks, of these digits or rays here described, are on the ulnar side of the primary rays; that, however, is not an absolute rule, as many passerine birds have a pre-index nearly as large, and quite as independent, as their large post-index; and both these supplementary rays are attached to the main metacarpal, the one on the front or radial side being attached much further down than that on the ulnar side. These unexpected complexities of the transformed fore-paw in birds are being traced out in the whole class, and will be published in due time.*

I have one word more to say about these secondary forkings of the rays of the fore-limb. If they were merely adaptive enlargements for the sake of the setting in of the quills, why did Nature create new cartilaginous rays, ossify them autogenously, and then obliterate all signs of their temporary independence? Any slight extension of periosteal bone from the normal rays would have sufficed to produce these flanges and interosseous bridges. No expenditure of the morphological force was needed for such after-touches as these. Thus the teleologist is quite at fault here: there is no scent: another hound may cry upon the right track, but he will have to be one of the ontological breed.

Hip-girdle of Uria troile, *Embryos and Adult.*

This part of the skeleton, including the sacral vertebræ, is of great interest; both the pelvis and the dorsal vertebræ are in accord; both suggest a nearer relationship of the Alcidæ to the gulls on one hand, and to the penguins on the other, than to those important Pygopods, the Colymbidæ and Podicipitidæ, that seem to be the true descendants of the extinct Hesperornithidæ. I shall return to this subject in describing the pelvis of the adult.

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* With regard to secondary rays in the fore-paw of extinct reptiles, Dr. G. Baur (see my reference to his views, Proceedings, Royal Society, 1888, p. 323) insists upon their presence on the ulnar side, only, of the primary rays. Mentioning this to Professor H. G. Seeley, I obtained from him a distinct denial of the truth of Dr. Baur's assertion. I must say that what I have seen in so many passerine birds makes me feel sure that they may occur on both sides.

In the first stage of *Uria troile* the hip-plate (Plate VIII., fig. 1) is, as to form, in the struthious condition; the three main bars, or plates, are distinct rays behind, the ischium (*isc.*) not having become fused with the post-ilium (*pt.i.*). At this stage the hip-girdle is just in extreme contrast with that of the adult loon (*Colymbus septentrionalis*), in which the post-ilium is two and a-half times the length of the pre-ilium. In this embryo of the guillemot the post-ilium is not two-thirds the length of the pre-ilium, and, in the adult, is only three-fourths its length—exactly the same proportion as in *Eudyptes chrysocome.** This pelvis (Plate VIII., fig. 1) has dilated pre-ilia, and contracted post-ilia.†

Behind the rounded free ends of the pre-ilia the plates contract, and then dilate to form the fore part of the acetabulum; beyond which they grow along the sides of the sacrum for some distance, and then diverge and end in a pointed process, whose lower margin is notched. Below the post-ilium the ischium (*isc.*) runs backwards as a broadening flap of cartilage, which also ends in a point at some distance behind the post-ilium. The pubis (*pb.*) is less than half the breadth of the ischium; and it goes still further back, so as to be almost twice the length of the post-ilium; it is terete, not flat, and ends in a point. Nearly the middle third of the pubis is ossified; the ilium is ossifying along its outer edge; and the ischium has a small bony patch over the proper obturator space.

Some curious changes are seen in the hip-plate in Stage 2 (Plate VII.). The two moieties are strongly clamped upon the sacrum, and contract in upon the caudal vertebræ also. The osseous centres are much enlarged, and the iliac bone is now some distance behind the acetabulum; the three rays are all distinct behind. But the most remarkable change has taken place in the pubis; it is crumpled in exactly the same manner as the inter-trabecular rostrum and the meckelian rods in the same stage (Plate VI., figs. 4 and 6). This crumpling is apparently due to the faster growth of this part as compared with the structure with which it is bound up; in the adult the pubis is very long. In Stage 3 (Plate VIII., figs. 2, 3) the general growth has gone on, and one of the pubes—the left—has become dilated at its end; in the adult both are dilated, as in the Anatidæ. The ilia coalesce with the sacrum, but leave a large groove open, right and left, in the fore-part of the pelvis, above; the post-ilia reach the third caudal vertebra, so independent is the boundary between the uro-sacral and the caudal region. The slender pubes keep free from the ischia; they are arched upwards, and the lower edge of the ischia is concave, parallel with that arching.

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* Morrison Watson: "Challenger Reports" (*Spheniscidæ*), Zoology, vol. vii., Plate VII., figs. 7 and 8.

† The figure is from an outspread preparation. This is corrected in Stage 2, Plate VII., and in Stage 3, Plate VIII., figs. 2, 3.

If we compare the pelvis of one of these Alcidæ with that of a gull and of the plovers,[*] it is evident that the Alcine pelvis is but a contraction of the Larine, as the latter is but that of a plover made narrower. But the pelvis of the razor-bill and penguin are still more alike;[†] whilst the pelvis of Colymbus[‡] is seen at once to be a modern form of that of Hesperornis.[§] Also, let it be noted, that, whilst the Anatidæ agree with the grebes, loons, and Hesperornis, in having cylindroidal dorsal vertebræ, they also agree in having the post-ilium much longer than the pre-ilium.[||]

These are only a few of the difficulties that rise up to confuse the classifier of the Palmipeds; they are more than doubled when we bring in the Procellariidæ and the Pelecaniidæ, using the latter term in its widest sense.

Hind-limb in Uria troile; *Embryos and Adult.*

In Stage 1 this part is still in its archaic or dinosaurian condition. Most of the primary elements of the limb are uncombined, but they are placed together ready for confluence (Plate 8, figs. 4, 5). The fibula has retreated upwards; the tibia (*t.*) having drawn the nourishment out of it, this latter rod has the upper part of the tarsus articulated with it. The three proximal tarsals, tibiale, fibulare, and intermedium (*tb.*, *fbe.*, *i.*) are traceable, but are not now distinct nuclei; the supero-anterior element, the intermedium, is short, as in the common chick, not long, as in the goose tribe and the Ratitæ; it is an obliquely-placed diamond-shaped plate attached below to the fibulare, and overlapping the outer part of the tibia above.

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[*] See Shufeldt, *op. cit.*, Part ii., Plates X. and XI.

[†] Watson: *op. cit.* Plate VII., figs. 7, 8.

[‡] Brandt: *op. cit.*, Plate XVI.

[§] Marsh: *op. cit.*, Plates X. and XI.

[||] See Plates III.-V. of the present Paper; and Shufeldt, Proceedings, U. S. Nat. Mus., vol. xi., pp. 225, 226, figs. 6–8.

Below these the single distal tarsal forms (*d.t.*) a sinuous cap to the three developed metatarsals (*m.t.*$^{2-4}$); and behind and between the two masses on the inner tibial side, there is a small nucleus answering to the scaphoid or centrale (*c.*), and a small elevation on the fibular side of the distal tarsal and fourth metatarsal (*d.t.*, *m.t.*^{4}); this is all that is left of the fifth metatarsal (*m.t.*^{5}). At the lower third of the second metatarsal (*m.t.*^{2}) a small milioline grain of cartilage is all that is left of the first metatarsal (*m.t.*^{1}), and thus the outer and inner digits are suppressed. The other three are normal, with their three, four, and five phalanges (Plate VII.); but their metatarsals (*m.t.*$^{2-4}$) are distinct, and diverge so as to produce a sprawling or reptilian foot; more than the middle third of these metatarsals is ossified. In *Alca torda* at this stage (Plate IX., fig. 8) the proximal tarsal mass is shown, and the separate tendon-bridge. In Stage 2 (Plate VII., and Plate VIII., fig. 6) the parts are larger and more ossified: the characteristic change is seen in the metatarsals (*m.t.*$^{2-4}$) which have been squeezed together, so to speak, closely faggoted into a single shank, and flattened when they adhere to each other. In Stage 1 the third was a little behind the other two; it is the largest, and has the largest head, which projects considerably behind the other. Above these rods the distal tarsal has grown up a front to form the very avian intercondyloid knob. The small oval intermedium (*i.*) is still markedly separate from the fibulare or outer condyle. The centrale (*c.*) is now merely a thickening in the inner part of the growth of the general tendon-sheaths for the plantar tendons.

In Stage 3 (Plate IX., figs. 9, 10) the common mass of the tibiale and fibulare (*tb.*, *fbe.*), and the tendon-bridge are still cartilaginous, and will be for a good while to come; but the intermedium is now ossified by ectostosis, and overlaps the tibia antero-externally. The arrested first metatarsal (*m.t.*^{1}) is still unossified.

In the adult these parts are all ossified and ankylosed together; even the secondary tendon-bridge; the intermedium can be traced as a small triangular projection above the inner condyle. Even in old Alcidæ, the first metatarsal is visible as a small, flattish grain of bone. In *Fratercula arctica* it is 1 millim. in diameter.

In the old guillemot (*Uria troile*) the patella is large and thick, 5 millims. high, and the same in width. The cnemial ridges of the tibia are strong and high, the fibula one-third shorter than the tibia, and the femur moderately long and gently curved. The shank is only three-fourths the length of the middle toe. The length of the toes is as follows:—Second, 35 millims.; third, 49 millims.; fourth, 46 millims.

The position of the guillemot, somewhere between the loon and the gull, may be illustrated by a comparison of the relative length of the three main divisions of the hind-limb:—

Femur.	Tibio-tarsus.	Tarso-metatarsus.
Larus argentatus, 59 millims.	109 millims.	64 millims.
Uria troile, 47 millims.	91 millims.	36 millims.
Colymbus septentrionales, 37 millims.	165 millims.	71 millims.

In each case the tibia has had about 5 millims. of its length added to it by the proximal tarsal mass, whilst the cnemial process has added: in the gull, 6 millims.; in the guillemot, 7 millims.; and in the loon, 42 millims. Here we see that in the loon the femur is so short that the tibio-tarsus is four and a-half times its length. The proportion in the gull is less than twice; and in the guillemot the femur is somewhat shorter relatively than in the gull.

I do not wish to lay too much stress on these measurements; I must remark on the extreme modification of the hind-limbs and pelvis in the loon, making it the isomorph of the seal (Phoca). But what is pertinent to the subject is, that it is not a modern specialization; it is as "old as the (Cretaceous) hills," and probably much older; for Hesperornis, that almost wingless and toothed loon, must have existed long enough to abort his wings and lose his sternal keel.

SUMMARY.

(*a*) *The Anatidæ and Alcidæ considered from an ornithological standpoint.*

Continuing my observations on the relationship of these two widely separated families of birds, I would reiterate the remarkable fact that the Anatidæ manifestly converge towards the gallinaceous group; that they have the struthious division of the Ratitæ obliquely below them; whilst the Alcidæ are related to a large and varied group of existing families, but, in their ancestry, belong somewhere between those two extremely dissimilar extinct families, the Hesperornithidæ and the Ichthyornithidæ. The revelation made by the precious remains of those two ancient toothed types throws a bright light on one side of these questions of origin and relationship, but intensifies the darkness on the other side. The glare makes some things appear darker than they were before those treasures were unearthed.

The loss of teeth is evidently a comparatively modern specialization, as compared with the general structure of the bird; the Anatidæ, however, have had time, not only to lose their true teeth, but also to gain false teeth, or horny imitations—*succedanea*—in their place. The Alcidæ, however, are no losers; their shorter cultrate elastic beak is a most mobile and strong pair of fish scissors, much more effective than the long, toothed jaws of an Ichthyornis could have been.

Higher up in the class the gain has been exceedingly great: the house-martin, the chaffinch, the long-tailed titmouse, and the tailor-bird owe the possibility of their exquisite architectural skill to their toothless jaws. But maxillary armature is but a small part of a vertebrated organism; the morphologist has much more to do than to study teeth.

Diagrams of "family trees" do not help us much; they are easy to make; the real difficulty lies in proving that they illustrate anything that ever actually took place in Nature.

I am under the impression that penguins never possessed quills, and that their adaptation to aquatic life, and their great power of diving, took place much earlier in their ancestral history than in the case of the auks and guillemots—birds that tend to become a sort of palæarctic penguin, but never quite lose the marks of their former adaptation to a more terrestrial life. I conceive of their ancestors in amphibious or limicolous birds; and I imagine the forefathers of gulls, plovers, rails—the auk tribe—as being very much alike, and very nearly related.

I am the more led to this way of thinking by what is seen in those remarkable Limicolæ, the sheath-bills (Chionis), and also in their near relatives Thinocorus and Attagis. These archaic neotropical plovers (Limicolæ) are aberrant and almost extinct types. In the case of *Chionis alba* the skull is extremely like that of the razor-bill (*Alca torda*)—so much so that, if it had come to me as a fossil, nothing more being known of the bird but the remains of its skull, I should unhesitatingly have put it amongst the Alcidæ. I have already referred to the pelvis of this genus, and of the plovers and gulls, in describing that of Uria.* But the penguins, with their extreme specialization as the highest form of divers, must, it appears to me, have been penguins since the day they acquired their peculiar mantle. They were *amphibio-Dipnoans;* they became transformed into what we now see—perchance they were somewhat clumsier at first.

It is in the hind-quarters that the extinct ornithoscelidan reptiles approach the bird in their organization; in the penguin those parts are, even in the adult, least modified from the condition seen in these reptiles. Their spine, in the dorsal region, has the archaic opisthocœlian articulations; their skull is of a generalized form, a little more primitive than that of a razor-bill; and the appearance of the head in its feathers is much like that of the large embryo of the guillemot (Plate IX., fig. 18).

All the penguins are alike in everything that is important;† of the

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* See Shufeldt, *op. cit.*, Part x., xi., for figures of the pelvis in *Chionis minor*.

† It is remarkable that the gigantic extant penguin (Palæeudyptes—see Huxley, Proceedings, Geological Society, 1859, pp. 670–676) should, like the great ostrich, have only two toes.

Alcidæ only one, *Alca impennis*, became transformed into the likeness of a penguin; the specialization of the family has been imperfect, as compared with the penguins, and, as I believe, took place later in time.

Returning to the duck tribe, and again referring to the fact that they evidently come from a stock closely related to that from which the fowl-tribe sprung, we must either give up the doctrine of the evolution of all these various types, in time, or make ourselves satisfied that some low, unsightly amphibious fowl—a wader of some sort—gave rise to two tribes, the Anatine and the Gallinaceous; and was thus, at once, the ancestor of the swan, on one hand, and of the peafowl on the other. This is enough to stagger the faith of the most robust Darwinian; but true faith laughs at impossibilities—that is, at what seem to be such to our scant knowledge and limited reason.

Without losing ourselves in the past, there is much in the present to interest us. The two groups treated of in the present Paper are, for ornithological purposes, very instructive, being so sharply defined from each other, albeit they are both made up of forms that are adapted to aquatic life. The Anatidæ, which are more or less terrestrial also, are mainly swimmers, and some of them, as the swans, are sailors. The Alcidæ are not more fit for land than the eared seals (Otariæ); but they can fly, and they can dive—are equally at home and at ease in the rarer or the denser medium. For taxonomic use the skeletal parts come in very usefully; Professor Huxley has shown us how to turn these parts to account.

Now, these two families are, in respect of their osteological structure, sharply divided from each other: the points in which they agree are fewer than those in which they disagree:—(*a*) The whole skeleton is much stronger, and more pneumatic, in the Anatidæ than in the Alcidæ. (*b*) The Anatidæ are desmognathous and holorhinal; they have permanent anterior basipterygoids, an azygous vomer, massive basitemporals, produced posterior angular processes to their mandible, dilated jaws covered with horny lamellæ, cylindroidal dorsals, a furcula composed of clavicles only, and the post-ilium much longer than the pre-ilium. The Alcidæ are schizognathous and schizorhinal; they have temporary middle basi-pterygoids, a double vomer, delicate basitemporals, arrested posterior angular processes, contracted and cultrate jaws, opisthocœlous dorsals, a considerable interclavicle in the furcula, and their post-ilium is much shorter than their pre-ilium. Now, if the ornithologist will add these differences to those which are familiar to him in the superficial structure of these birds, they will greatly strengthen and enrich his taxonomy. Also, looking on this picture and on that, he will be able to judge where these two families should be set in the class, so that his grouping of the plumy tribes may be as "goodly as the tents of Jacob."

We can now leave the fowler, and turn to that other labourer, who works with a spade and a pickaxe: the palæontologist is asking what all this modification of a reptilian type means, and how it bears on his special work.

(*b*) *The Anatidæ and Alcidæ considered from an ontological standpoint.*

If it has become clear that the birds are not sharply separated from the reptiles, it has also become equally clear that the reptiles are not sharply separated from the amphibians.

As to its hind-quarters,* the humming-bird is but a Dinosaurian—a sort of Iguanodon, intensely ossified, albeit the latter may be as large as a whale, and the former no larger than a "bumming bee." But vertebrated animals have fore-quarters as well as hind-quarters; they have also a neck and a head; and, if we are to grow our bird from a true reptile, lessening its size, warming its blood, and dotting it with feathers, we must graft the head of the Ichthyosaurus, and the neck of the Plesiosaurus, on to the hind-quarter of the Iguanodon. Now, I contend that Nature did not work in this fashion. The bird had its own ancestors as much as Man had his: *he* is not indebted to an archaic gorilla for his existence; and the bird owes nothing, in that way, to your Iguanodon, Plesiosaurus, and Ichthyosaurus. So much is clear. It is not clear as to how Nature did work: it is a perfect work, but she has concealed her art. If, however, her beginnings were mean and small, her latter end has greatly increased. We dream, scientifically, of the primordial amphibio-Dipnoan—the imagined common ancestor of all the reptiles and of all the birds; we see and handle the results; and, if the blind, unconscious morphological force could see and speak, it would pronounce all these forms "very good."

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* See Huxley, Proceedings Geological Society, 1869, p. 31.

These remarks are general; we may, however, make some special attempt at showing that they are "words of soberness."

The development of the bird is not a process that takes place suddenly, at a leap; but is a long, slow, metamorphic process. Each stage in the development of a chick shows us the isomorph of some low adult form; each point gained gives us a quasi-historical record of some ancient type that must have belonged to a far lower platform of life than the creature whose growth we are tracing.* Then naked, dry teleology is of very little use to the morphologist; it serves him so badly that he is in danger of casting it aside altogether. Nature will not form her high and noble type all at once; she will "spin her yarn" slowly and with solemnity, working as with a needle in the dark. When the "tapestry" is perfected, then we have the pheasant and the pea-fowl, the trogon and the humming-bird.

That which has dominated the whole form is the wing. Yet, embryology shows us that this is merely the modified fore-paddle of a low gill-breathing amphibian—a nailless fore-paw. But the nails or claws do appear; yet, in the wing, they are out of place; and this reptilian stage is only transient. If the bird is, indeed, the child of the reptile, it must forget its father's house; it must proceed beyond its progenitor. But the reptile, as a rule, has a most perfect and typical "hand" or fore-foot, with accurate rows of carpals and metacarpals, and with digits in fixed order and number; in front two, then three, four, five, and once again, four in the hinder side.

We have no sign of atavism or degradation, of abortion or of suppression, in the perfect fore-foot of a lizard: in a bird all these things turn up, and startle the morphologist, whose hard duty it is to interpret them.

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* See Philosophical Transactions, 1869, pp. 803, 804.

But, if we are willing to see the bird's wing grow, not out of a perfect and typical cheiropterygium, but out of an ichthyopterygium in an unsettled state, ready for transformation into the higher type of limb, then the difficulty is solved. It was a fish-paddle; it was not to become a fore-foot; it did change into the framework of a bird's wing; in that respect it is a perfect thing; as a paw, it is an abortion.

But an organism moves together in all its parts, if it moves at all; and thus we see that, in correlation to the profoundly modified fore-limb, every other part of this feathered creature has suffered changes. I need not here recapitulate the details of this beautiful metamorphosis.*

As bearing upon the evolution of both the bird's wing and the fore-paw of the mammal, including the human hand, the most complete cheiropterygium in existence, I would again refer to M. Dollo's memoir on *Iguanodon beruissastensis*,† in which the five digits of the fore-arm have their normal number of reptilian segments (phalanges) in the first and second, whilst, as in mammals, the fourth and fifth keep to three only. This type also shows how a digit may become a spur; for the ungual phalanx of the pollex turns inwards and upwards, and forms a large defensive spur. And this is so closely set upon the very solid and simple carpus as to be little different from the spur of Palamedea and Chauna, among modern birds. Indeed, it is difficult to say whether the small bone at the base of the ungual phalanx in that reptile is a metacarpal or a proximal phalanx, or both in one, either fused or primarily connate. But some of these Dinosaurs have the normal number of phalanges in their fore-paw, as in the existing Lacertilia.*

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* Besides the references to works and papers in the body of this memoir, I would here especially refer to some invaluable pieces of morphological work:—Morse, Dr. Edward S., "On the Tarsus and Carpus of Birds."—Ann. Lyc. Nat. Hist. New York. Vol. x., 1878; pp. 141–158, Plates IV., V. Do., "On the Identity of the Ascending Process of the Astragalus in Birds with the Intermedium."—Ann. Mem. Bost. Soc. Nat. Hist., 1880, pp. 1–10, Plate I. Kehrer, Gustav, "Beiträge zur Kenntniss des Carpus und Tarsus der Amphibien, Reptilien, und Säuger," Berichte der naturforschenden Gesellschaft zu Freiburg, i. B., Band i., pp. 1–14, Plate IV. Howes, Professor G. B., "On the Carpus and Tarsus of the Anura."—Proceedings, Zoological Society, 1888, pp. 141–182, Plates VII.–IX. Bardeleben, Professor Karl, "On the Pre-pollex and Prehallux, with observations on the Carpus of *Theriodesmus phylarchus*."—Proceedings, Zoological Society, 1889, pp. 259–262, Plate XXX. Baur, Dr. G., "Ueber den Ursprung der Extremitäten der Ichthyopterygia. Bericht über die xx. Versammlung des Oberrheinischen geologischen Vereins," pp. 1–4, figs. 1–4.

† Bull. Mus. Roy. Hist. Nat. Belg., t. i., Plate IX.; and t. ii., Plates III.–V.

I refer to these valuable Papers of Marsh and Dollo both as regards the limbs and the limb-girdles; the foreshadowing of the remarkable rotation of the pubis and ischium, so characteristic of birds, being seen also to a less degree in these huge reptiles, which seem, in this respect, to have had a tendency bird-ward, but missed their mark in respect of flying, a function for which they were just as little adapted as the existing whales.

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* See Amer. Jour. of Science and Art, vol. xvii., 1879, pp. 85–92, Plates III.–X.; *ibid.*, vol. xviii., Plate III., pp. 501–505; and *ibid.*, vol. xix., Plates VI.–XI., pp. 83–87, and 253–259.

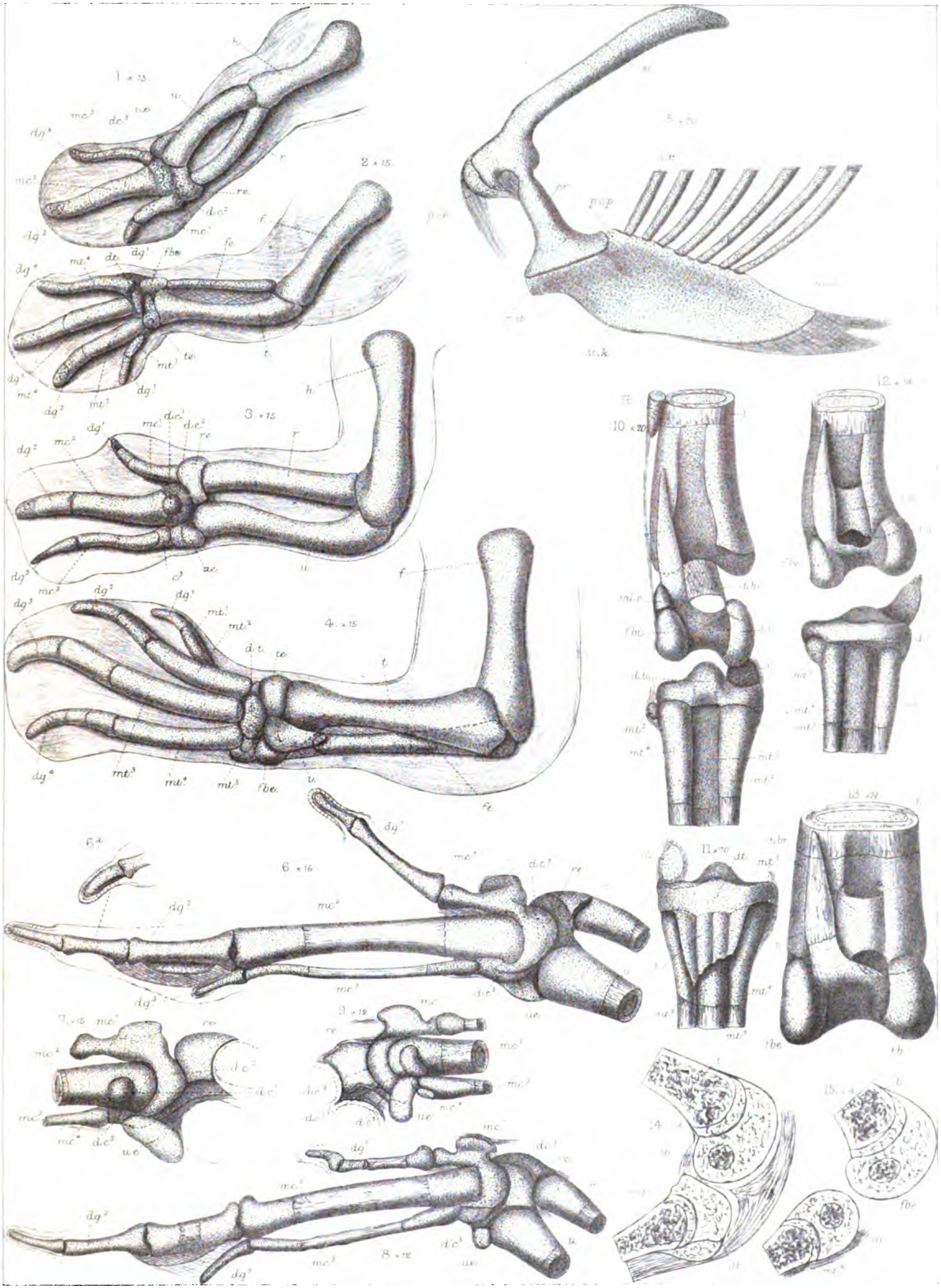
PLATE I.

MORPHOLOGY OF THE DUCK AND THE AUK TRIBES.

LIST OF ABBREVIATIONS.

[*The Roman Numerals indicate Nerves and their Foramina.*]

ac.	Acetabulum.
ac.p.	Acromial process of scapula.
ag.	Angulare.
al.e.	Aliethmoid.
al.n.	Alinasal.
ar.	Articulare.
al.s.	Alisphenoid.
al.sp.	Aliseptal.
a.o.	Antorbital.
a.s.c.	Anterior semicircular canal.
at.	Atlas.
a.t.r.	Anterior tympanic recess.
au.	Auditory capsule.
ax.	Axis.
b.h.br.	Basi-hyobranchial.
b.hy.	Basihyal.
b.o.	Basioccipital.
b.pg.	Basipterygoid.
br.	Ceratobranchial.
b.s.	Basisphenoid.
b.t.	Basitemporal.
c.	Centrum and centrale.
c.a.	Uncinate process.
cd.v.	Caudal vertebra.
c.f.c.	Cranio-facial cleft.
c.hy.	Cerato-hyal.
cl.	Clavicle.
co.	Columella.
cp.	Carpal.
cr.	Coracoid and cervical rib.
cr.g.	Crista galli.
c.ty.	Tympanic cavity.
c.u.	Centralo-ulnare.
c.v.	Cervical vertebræ.
d.	Dentary.
d.c.	Distal carpal.
dg.	Digit.
d.t.	Distal tarsal.
d.r.	Dorsal rib.
d.s.v.	Dorso-sacral vertebræ,
d.v.	Dorsal vertebra.
e.eth.	Ectoethmoid.
e.n.	External nostril.
e.o.	Exoccipital.
Eu.	Eustachian opening.
f.	Frontal and femur.
fb.	Fibula.
fbe.	Fibulare.
f.m.	Foramen magnum.
fr.	Furcula.
g.	Ganglion.
h.	Humerus.
h.s.c.	Horizontal semicircular canal.
i.	Intermedium.
i.a.c.	Interarcticular cartilage.
i.a.p.	Internal angular process.
ic.	Intercentrum.
i.c.	Internal carotid foramen.
i.cl.	Interclavicle.
il.	Ilium.
i.o.f.	Inter-orbital fenestra.
i.pa.	Inter-palatine.
i.r.	Intermedio-radiale.
isc.	Ischium.
i.tb.	Inferior turbinal.
i.tr.	Inter-trabecula.
j.	Jugal.
l.	Lachrymal.
l.c.	Lachrymal canal.
l.s.v.	Lumbo-sacral vertebræ.
m.	Mouth.
mk.	Meckel's cartilage.
m.st.	Metasternum.
mt.c.	Metacarpal.
mt.t.	Metatarsal.
mx.p.	Maxillo-palatine.
n.	Nasal.
n.a.	Neural arch.
nc.	Notochord.
n.f.	Nasal floor.
n.px.	Nasal process of pre-maxillary.
ob.f.	Obturator fenestra.
oc.c.	Occipital condyle.
od.p.	Odontoidprocess.
op.	Opisthotic.
o.s.	Orbitosphenoid.
p.	Parietal.
pa.	Palatine.
p.a.p.	Posterior angular process.
pa.s.	Parasphenoid.
pb.	Pubis.
p.cl.	Posterior clinoid process.
pc.p.	Postcoracoid process of sternum.
pcr.	Precoracoid.
p.c.s.	Pre-costal process of sternum.
p.e.	Perpendicular ethmoid.
pg.	Pterygoid.
ph.	Phalanx.
p.n.	Prenasal rostrum.
pr.i.	Pre-ilium.
pro.	Prootic.
pr.z.	Pre-zygaphophysis.
p.s.	Presphenoid.
p.s.c.	Posterior semicircular canal.
pt.i.	Post-ilium.
pt.z.	Post-zygapophysis.
px.	Premaxilla.
q.	Quadrate.
q.j.	Quadrato-jugal.
r.	Radius.
r.b.s.	Rostrum of basisphenoid (= rostrum of parasphenoid).
rc.	Radiale.
r.st.	Rostral process of sternum.
s.ag.	Supra-angulare.
sc.	Scapula.
s.n.	Septum nasi.
s.i.f.	Sacro-ischiatic fenestra.
s.o.	Supra-occipital.
sp.	Splenial.
sp.o.	Sphenotic.
sq.	Squamosal.
s.r.	Sacral rib.
s.sc.	Supra-scapula.
st.	Sternum.
st.k.	Sternal keel.
s.v.	Sacral vertebra.
tb.	Tibial.
t.c.	Tendon-canal.
te.	Tibiale.
t.co.	Tympanic wing of occipital.
ts.	Tarsal.
u.	Ulna.
ue.	Ulnare.
u.s.v.	Uro-sacral vertebræ.
v.	Vomer.
v.a.	Vertebral artery.
v.b.	Vestibule.



W K Parker del ad nat. M P Parker, lith.

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ANATIDÆ

PLATE II.

MORPHOLOGY OF THE DUCK AND THE AUK TRIBES.

EXPLANATION OF PLATE II.

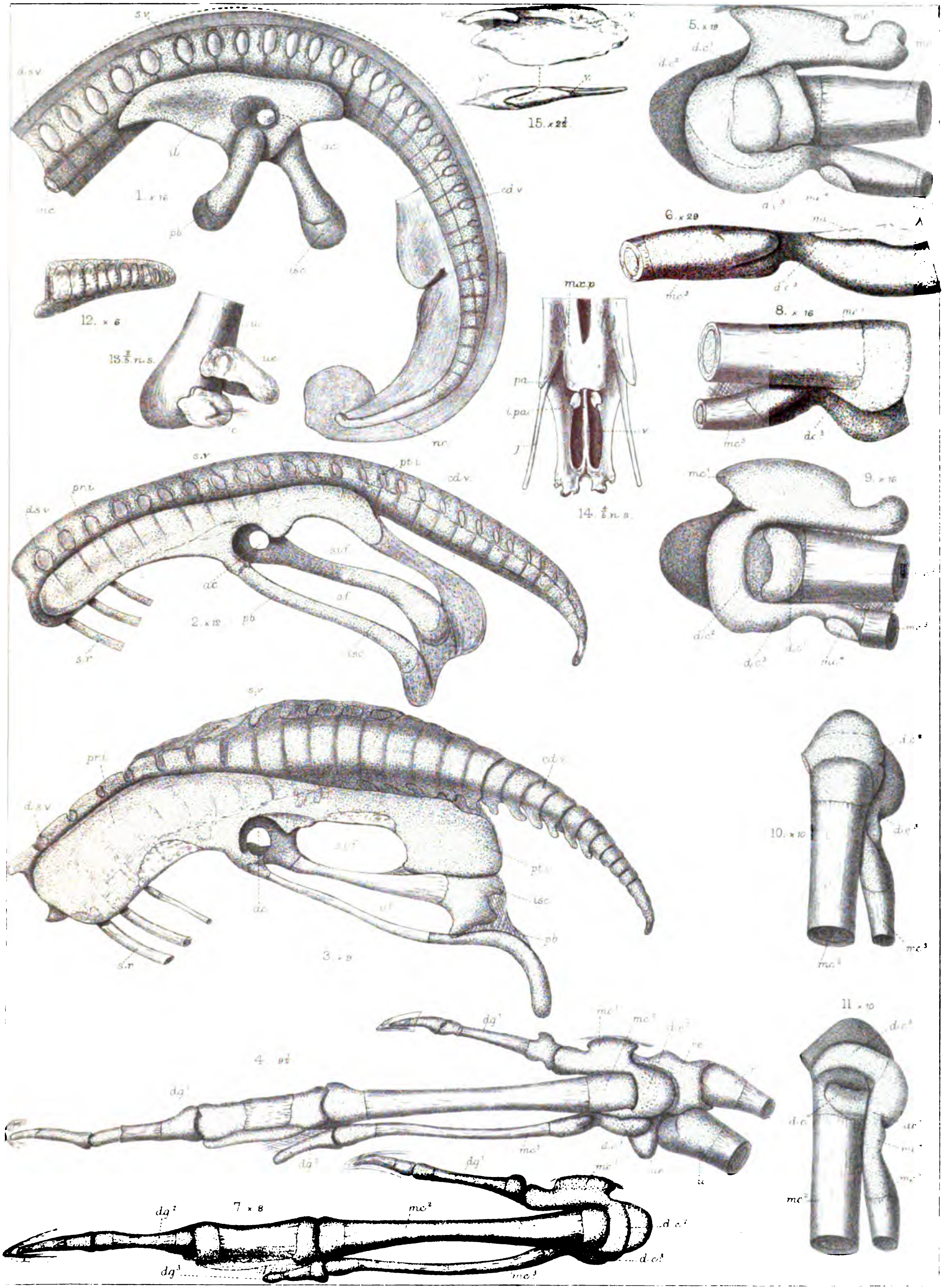
Fig.		Number of times magnified.
1.	***Anas boschas;*** 1st stage; left side of pelvis and hinder part of spine, outer view,	16 diameters.
2.	The same; 2nd stage; a similar view of the same parts,	12 diameters.
3.	The same; 3rd stage; twelve days' incubation; a similar view of the same parts, with the pelvis somewhat dislocated from the spinal column,	9½ diameters.
4.	The same; 5th stage; eighteen days' incubation; distal part of left wing, outer view,	9½ diameters.
5.	The same; part of same object, inner view,	19 diameters.
6.	The same; part of the same as fig. 4,	29 diameters.
7.	The same; 6th stage; ripe embryo distal part of wing, outer view,	8 diameters.
8.	The same; part of same preparation, outer view,	16 diameters.
9.	The same; same object; inner view,	16 diameters.
10.	The same; 7th stage; proximal part of manus, outer view,	10 diameters.
11.	The same; same object; inner view,	10 diameters.
12.	The same; 7th stage; another specimen; coccygeal tract of spine; side view,	5 diameters.
13.	***Chauna chavaria;*** adult; distal end of ulnar, with carpals,	¾ Natural size.
14.	***Cygnus atratus;*** part of palate,	¼ Natural size.
15.	***Anser palustris*** six weeks old; vomer and antero-superior additional ossicle; lateral and upper views,	2½ diameters.

[For List of Abbreviations used on this Plate, *vide* over.]

LIST OF ABBREVIATIONS.

[*The Roman Numerals indicate Nerves and their Foramina.*]

ac.	Acetabulum.
ac.p.	Acromial process of scapula.
ag.	Angulare.
al.e.	Aliethmoid.
al.n.	Alinasal.
ar.	Articulare.
al.s.	Alisphenoid.
al.sp.	Aliseptal.
a.o.	Antorbital.
a.s.c.	Anterior semicircular canal.
at.	Atlas.
a.t.r.	Anterior tympanic recess.
au.	Auditory capsule.
ax.	Axis.
b.h.br.	Basi-hyobranchial.
b.hy.	Basihyal.
b.o.	Basioccipital.
b.pg.	Basipterygoid.
br.	Ceratobranchial.
b.s.	Basisphenoid.
b.t.	Basitemporal.
c.	Centrum and centrale.
c.a.	Uncinate process.
cd.v.	Caudal vertebra.
c.f.c.	Cranio-facial cleft.
c.hy.	Cerato-hyal.
cl.	Clavicle.
co.	Columella.
cp.	Carpal.
cr.	Coracoid and cervical rib.
cr.g.	Crista galli.
c.ty.	Tympanic cavity.
c.u.	Centralo-ulnare.
c.v.	Cervical vertebræ.
d.	Dentary.
d.c.	Distal carpal.
dg.	Digit.
d.t.	Distal tarsal.
d.r.	Dorsal rib.
d.s.v.	Dorso-sacral vertebræ,
d.v.	Dorsal vertebra.
e.eth.	Ectoethmoid.
e.n.	External nostril.
e.o.	Exoccipital.
Eu.	Eustachian opening.
f.	Frontal and femur.
fb.	Fibula.
fbe.	Fibulare.
f.m.	Foramen magnum.
fr.	Furcula.
g.	Ganglion.
h.	Humerus.
h.s.c.	Horizontal semicircular canal.
i.	Intermedium.
i.a.c.	Interarcticular cartilage.
i.a.p.	Internal angular process.
ic.	Intercentrum.
i.c.	Internal carotid foramen.
i.cl.	Interclavicle.
il.	Ilium.
i.o.f.	Inter-orbital fenestra.
i.pa.	Inter-palatine.
i.r.	Intermedio-radiale.
isc.	Ischium.
i.tb.	Inferior turbinal.
i.tr.	Inter-trabecula.
j.	Jugal.
l.	Lachrymal.
l.c.	Lachrymal canal.
l.s.v.	Lumbo-sacral vertebræ.
m.	Mouth.
mk.	Meckel's cartilage.
m.st.	Metasternum.
mt.c.	Metacarpal.
mt.t.	Metatarsal.
mx.p.	Maxillo-palatine.
n.	Nasal.
n.a.	Neural arch.
nc.	Notochord.
n.f.	Nasal floor.
n.px.	Nasal process of pre-maxillary.
ob.f.	Obturator fenestra.
oc.c.	Occipital condyle.
od.p.	Odontoidprocess.
op.	Opisthotic.
o.s.	Orbitosphenoid.
p.	Parietal.
pa.	Palatine.
p.a.p.	Posterior angular process.
pa.s.	Parasphenoid.
pb.	Pubis.
p.cl.	Posterior clinoid process.
pc.p.	Postcoracoid process of sternum.
pcr.	Precoracoid.
p.c.s.	Pre-costal process of sternum.
p.e.	Perpendicular ethmoid.
pg.	Pterygoid.
ph.	Phalanx.
p.n.	Prenasal rostrum.
pr.i.	Pre-ilium.
pro.	Prootic.
pr.z.	Pre-zygaphophysis.
p.s.	Presphenoid.
p.s.c.	Posterior semicircular canal.
pt.i.	Post-ilium.
pt.z.	Post-zygapophysis.
px.	Premaxilla.
q.	Quadrate.
q.j.	Quadrato-jugal.
r.	Radius.
r.b.s.	Rostrum of basisphenoid (= rostrum of parasphenoid).
re.	Radiale.
r.st.	Rostral process of sternum.
s.ag.	Supra-angulare.
sc.	Scapula.
s.n.	Septum nasi.
s.i.f.	Sacro-ischiatic fenestra.
s.o.	Supra-occipital.
sp.	Splenial.
sp.o.	Sphenotic.
sq.	Squamosal.
s.r.	Sacral rib.
s.sc.	Supra-scapula.
st.	Sternum.
st.k.	Sternal keel.
s.v.	Sacral vertebra.
tb.	Tibial.
t.c.	Tendon-canal.
te.	Tibiale.
t.so.	Tympanic wing of occipital.
ts.	Tarsal.
u.	Ulna.
ue.	Ulnare.
u.s.v.	Uro-sacral vertebræ.
v.	Vomer.
v.a.	Vertebral artery.
v.b.	Vestibule.



W.K.Parker. del ad nat. M.P.Parker lith.

ANATIDÆ.

PLATE III.

MORPHOLOGY OF THE DUCK AND THE AUK TRIBES.

EXPLANATION OF PLATE III.

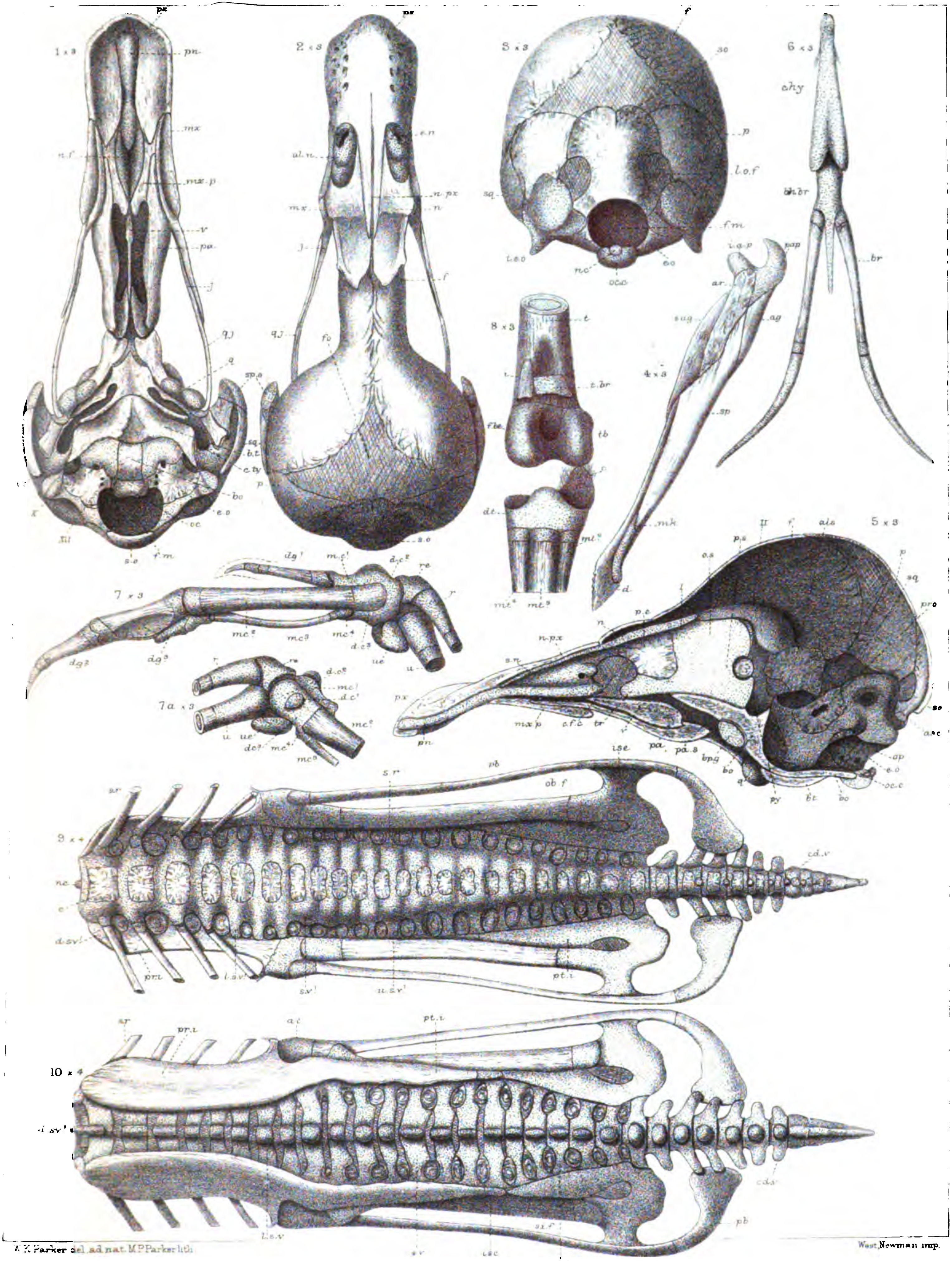
Fig.		Number of times magnified.
1.	*Cygnus nigricollis;* nearly ripe embryo; skull; lower view,	3 diameters.
2.	The same; same object; upper view,	3 diameters.
3.	The same; same object; back view,	3 diameters.
4.	The same; same skull mandible; inner view,	3 diameters.
5.	The same; same skull in vertical section,	3 diameters.
6.	The same; same skull, hyoid arch; upper view,	3 diameters.
7.	The same; distal part of wing; outer view,	3 diameters.
7*a*.	The same; part of same object; inner view,	3 diameters.
8.	The same; ankle-joint; front view,	3 diameters.
9.	The same; pelvis; lower view,	4 diameters.
10.	The same; same object; upper view,	4 diameters.

[For LIST OF ABBREVIATIONS used on this Plate, *vide* over.]

LIST OF ABBREVIATIONS.

[*The Roman Numerals indicate Nerves and their Foramina.*]

ac.	Acetabulum.
ac.p.	Acromial process of scapula.
ag.	Angulare.
al.e.	Aliethmoid.
al.n.	Alinasal.
ar.	Articulare.
al.s.	Alisphenoid.
al.sp.	Aliseptal.
a.o.	Antorbital.
a.s.c.	Anterior semicircular canal.
at.	Atlas.
a.t.r.	Anterior tympanic recess.
au.	Auditory capsule.
ax.	Axis.
b.h.br.	Basi-hyobranchial.
b.hy.	Basihyal.
b.o.	Basioccipital.
b.pg.	Basipterygoid.
br.	Ceratobranchial.
b.s.	Basisphenoid.
b.t.	Basitemporal.
c.	Centrum and centrale.
c.a.	Uncinate process.
cd.v.	Caudal vertebra.
c.f.c.	Cranio-facial cleft.
c.hy.	Cerato-hyal.
cl.	Clavicle.
co.	Columella.
cp.	Carpal.
cr.	Coracoid and cervical rib.
cr.g.	Crista galli.
c.ty.	Tympanic cavity.
c.u.	Centralo-ulnare.
c.v.	Cervical vertebræ.
d.	Dentary.
d.c.	Distal carpal.
dg.	Digit.
d.t.	Distal tarsal.
d.r.	Dorsal rib.
d.s.v.	Dorso-sacral vertebræ,
d.v.	Dorsal vertebra.
e.eth.	Ectoethmoid.
e.n.	External nostril.
e.o.	Exoccipital.
Eu.	Eustachian opening.
f.	Frontal and femur.
fb.	Fibula.
fbe.	Fibulare.
f.m.	Foramen magnum.
fr.	Furcula.
g.	Ganglion.
h.	Humerus.
h.s.c.	Horizontal semicircular canal.
i.	Intermedium.
i.a.c.	Interarcticular cartilage.
i.a.p.	Internal angular process.
ic.	Intercentrum.
i.c.	Internal carotid foramen.
i.cl.	Interclavicle.
il.	Ilium.
i.o.f.	Inter-orbital fenestra.
i.pa.	Inter-palatine.
i.r.	Intermedio-radiale.
isc.	Ischium.
i.tb.	Inferior turbinal.
i.tr.	Inter-trabecula.
j.	Jugal.
l.	Lachrymal.
l.c.	Lachrymal canal.
l.s.v.	Lumbo-sacral vertebræ.
m.	Mouth.
mk.	Meckel's cartilage.
m.st.	Metasternum.
mt.c.	Metacarpal.
mt.t.	Metatarsal.
mx.p.	Maxillo-palatine.
n.	Nasal.
n.a.	Neural arch.
nc.	Notochord.
n.f.	Nasal floor.
n.px.	Nasal process of pre-maxillary.
ob.f.	Obturator fenestra.
oc.c.	Occipital condyle.
od.p.	Odontoidprocess.
op.	Opisthotic.
o.s.	Orbitosphenoid.
p.	Parietal.
pa.	Palatine.
p.a.p.	Posterior angular process.
pa.s.	Parasphenoid.
pb.	Pubis.
p.cl.	Posterior clinoid process.
pc.p.	Postcoracoid process of sternum.
pcr.	Precoracoid.
p.c.s.	Pre-costal process of sternum.
p.e.	Perpendicular ethmoid.
pg.	Pterygoid.
ph.	Phalanx.
p.n.	Prenasal rostrum.
pr.i.	Pre-ilium.
pro.	Prootic.
pr.z.	Pre-zygaphophysis.
p.s.	Presphenoid.
p.s.c.	Posterior semicircular canal.
pt.i.	Post-ilium.
pt.z.	Post-zygapophysis.
px.	Premaxilla.
q.	Quadrate.
q.j.	Quadrato-jugal.
r.	Radius.
r.b.s.	Rostrum of basisphenoid (= rostrum of parasphenoid).
re.	Radiale.
r.st.	Rostral process of sternum.
s.ag.	Supra-angulare.
sc.	Scapula.
s.n.	Septum nasi.
s.i.f.	Sacro-ischiatic fenestra.
s.o.	Supra-occipital.
sp.	Splenial.
sp.o.	Sphenotic.
sq.	Squamosal.
s.r.	Sacral rib.
s.sc.	Supra-scapula.
st.	Sternum.
st.k.	Sternal keel.
s.v.	Sacral vertebra.
tb.	Tibial.
t.c.	Tendon-canal.
te.	Tibiale.
t.eo.	Tympanic wing of occipital.
ts.	Tarsal.
u.	Ulna.
ue.	Ulnare.
u.s.v.	Uro-sacral vertebræ.
v.	Vomer.
v.a.	Vertebral artery.
v.b.	Vestibule.



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ANATIDÆ.

PLATE IV.

MORPHOLOGY OF THE DUCK AND THE AUK TRIBES.

EXPLANATION OF PLATE IV.

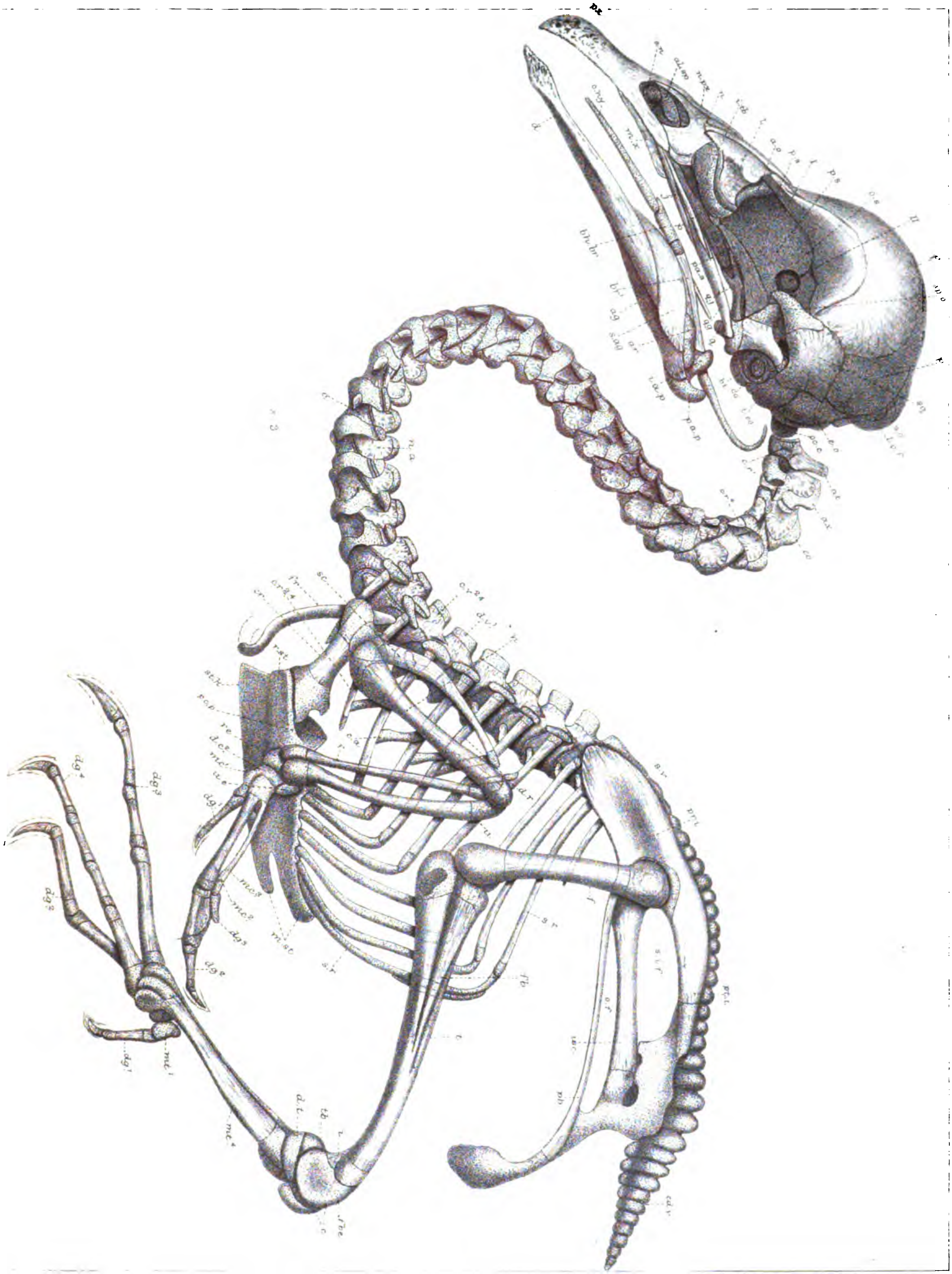
Fig.		Number of times magnified.
1.	*Cygnus nigricollis;* nearly ripe skeleton; side view, . . .	3 diameters.

[For LIST OF ABBREVIATIONS used on this Plate, *vide* over.]

LIST OF ABBREVIATIONS.

[*The Roman Numerals indicate Nerves and their Foramina.*]

ac.	Acetabulum.
ac.p.	Acromial process of scapula.
ag.	Angulare.
al.e.	Aliethmoid.
al.n.	Alinasal.
ar.	Articulare.
al.s.	Alisphenoid.
al.sp.	Aliseptal.
a.o.	Antorbital.
a.s.c.	Anterior semicircular canal.
at.	Atlas.
a.t.r.	Anterior tympanic recess.
au.	Auditory capsule.
ax.	Axis.
b.h.br.	Basi-hyobranchial.
b.hy.	Basihyal.
b.o.	Basioccipital.
b.pg.	Basipterygoid.
br.	Ceratobranchial.
b.s.	Basisphenoid.
b.t.	Basitemporal.
c.	Centrum and centrale.
c.a.	Uncinate process.
cd.v.	Caudal vertebra.
c.f.c.	Cranio-facial cleft.
c.hy.	Cerato-hyal.
cl.	Clavicle.
co.	Columella.
cp.	Carpal.
cr.	Coracoid and cervical rib.
cr.g.	Crista galli.
c.ty.	Tympanic cavity.
c.u.	Centralo-ulnare.
c.v.	Cervical vertebræ.
d.	Dentary.
d.c.	Distal carpal.
dg.	Digit.
d.t.	Distal tarsal.
d.r.	Dorsal rib.
d.s.v.	Dorso-sacral vertebræ,
d.v.	Dorsal vertebra.
e.eth.	Ectoethmoid.
e.n.	External nostril.
e.o.	Exoccipital.
Eu.	Eustachian opening.
f.	Frontal and femur.
fb.	Fibula.
fbe.	Fibulare.
f.m.	Foramen magnum.
fr.	Furcula.
g.	Ganglion.
h.	Humerus.
h.s.c.	Horizontal semicircular canal.
i.	Intermedium.
i.a.c.	Interarcticular cartilage.
i.a.p.	Internal angular process.
ic.	Intercentrum.
i.c.	Internal carotid foramen.
i.cl.	Interclavicle.
il.	Ilium.
i.o.f.	Inter-orbital fenestra.
i.pa.	Inter-palatine.
i.r.	Intermedio-radiale.
isc.	Ischium.
i.tb.	Inferior turbinal.
i.tr.	Inter-trabecula.
j.	Jugal.
l.	Lachrymal.
l.c.	Lachrymal canal.
l.s.v.	Lumbo-sacral vertebræ.
m.	Mouth.
mk.	Mockel's cartilage.
m.st.	Metasternum.
mt.c.	Metacarpal.
mt.t.	Metatarsal.
mx.p.	Maxillo-palatine.
n.	Nasal.
n.a.	Neural arch.
no.	Notochord.
n.f.	Nasal floor.
n.px.	Nasal process of pre-maxillary.
ob.f.	Obturator fenestra.
oc.c.	Occipital condyle.
od.p.	Odontoidprocess.
op.	Opisthotic.
o.s.	Orbitosphenoid.
p.	Parietal.
pa.	Palatine.
p.a.p.	Posterior angular process.
pa.s.	Parasphenoid.
pb.	Pubis.
p.cl.	Posterior clinoid process.
pc.p.	Postcoracoid process of sternum.
pcr.	Precoracoid.
p.c.s.	Pre-costal process of sternum.
p.e.	Perpendicular ethmoid.
pg.	Pterygoid.
ph.	Phalanx.
p.n.	Prenasal rostrum.
pr.i.	Pre-ilium.
pro.	Prootic.
pr.z.	Pre-zygaphophysis.
p.s.	Presphenoid.
p.s.c.	Posterior semicircular canal.
pt.i.	Post-ilium.
pt.z.	Post-zygapophysis.
px.	Premaxilla.
q.	Quadrate.
q.j.	Quadrato-jugal.
r.	Radius.
r.b.s.	Rostrum of basisphenoid (= rostrum of parasphenoid).
re.	Radiale.
r.st.	Rostral process of sternum.
s.ag.	Supra-angulare.
sc.	Scapula.
s.n.	Septum nasi.
s.i.f.	Sacro-ischiatic fenestra.
s.o.	Supra-occipital.
sp.	Splenial.
sp.o.	Sphenotic.
sq.	Squamosal.
s.r.	Sacral rib.
s.sc.	Supra-scapula.
st.	Sternum.
st.k.	Sternal keel.
s.v.	Sacral vertebra.
tb.	Tibial.
t.c.	Tendon-canal.
te.	Tibiale.
t.eo.	Tympanic wing of occipital.
ts.	Tarsal.
u.	Ulna.
ue.	Ulnare.
u.s.v.	Uro-sacral vertebræ.
v.	Vomer.
v.a.	Vertebral artery.
v.b.	Vestibule.



W.K. Parker del ad nat M.P Parker lith

West, Newman imp.

PLATE V.

MORPHOLOGY OF THE DUCK AND THE AUK TRIBES.

EXPLANATION OF PLATE V.

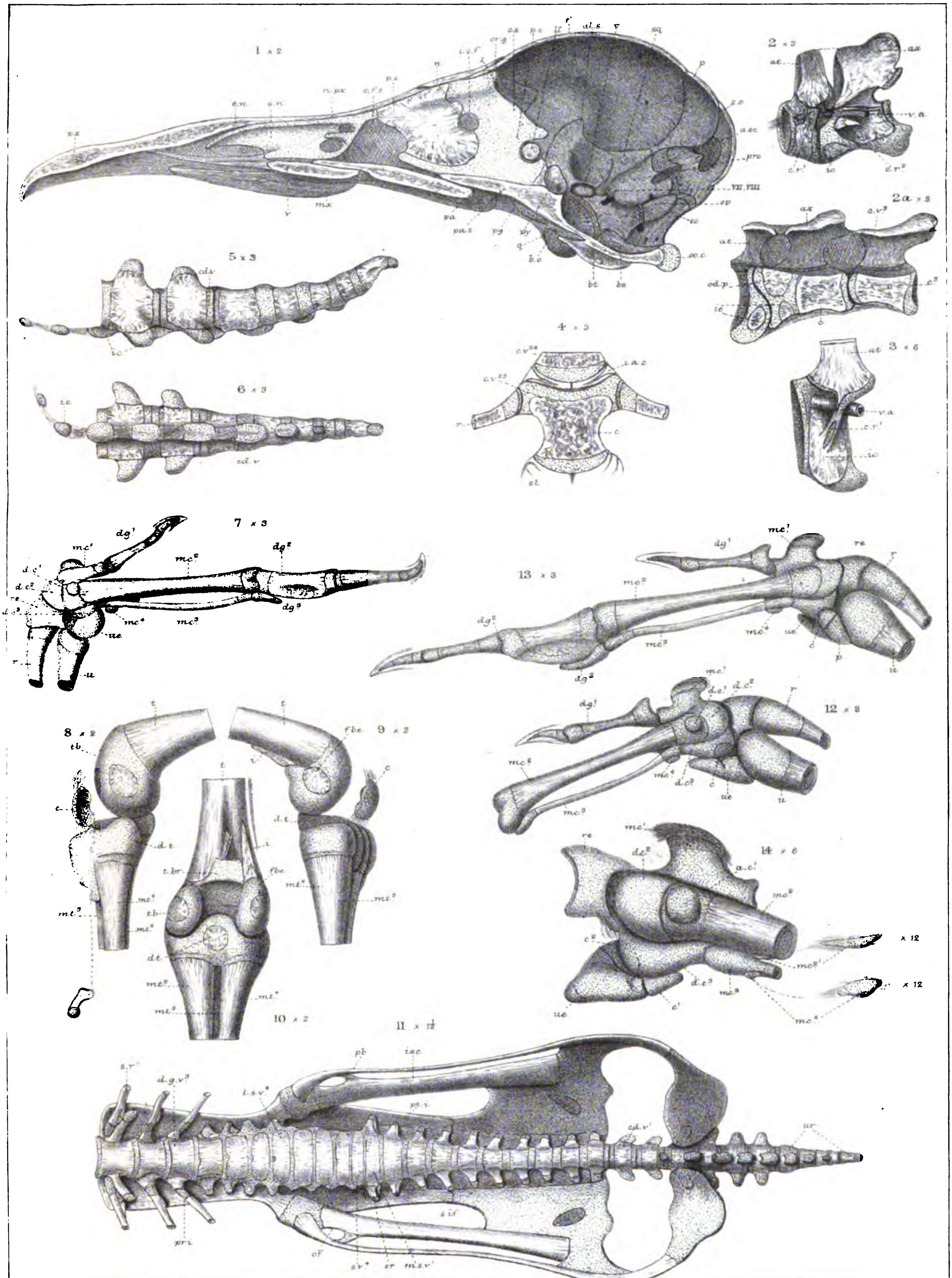
Fig.		Number of times magnified.
1.	*Cygnus olor ;* (*a*) cygnet 14¼ inches long ; skull in vertical section,	2 diameters.
2.	The same ; (*a*) atlas and axis ; side view,	3 diameters.
2*a*.	The same ; (*a*) section of the first three cervical vertebræ,	3 diameters.
3.	The same ; (*b*) cygnet 15 inches long ; part of atlas ; side view,	6 diameters.
4.	The same ; (*a*) centrum of 25th part of 24th cervical vertebræ ; horizontal section near lower surface,	3 diameters.
5.	The same ; (*b*) terminal part of spinal column ; side view,	3 diameters.
6.	The same ; same object ; lower view,	3 diameters.
7.	The same ; (*a*) distal part of wing ; inner view,	3 diameters.
8.	The same ; (*a*) ankle-joint ; inner view,	2 diameters.
9.	The same ; same object ; outer view,	2 diameters.
10.	The same ; same object ; front view,	2 diameters.
11.	The same ; (*b*) pelvis ; lower view,	1½ diameters.
12.	*Chloëphaga poliocephala*, ripe embryo ; distal part of wing ; outer view,	3 diameters.
13.	The same ; same object ; inner view,	3 diameters.
14.	The same ; part of fig. 13,	6 diameters.

[For LIST OF ABBREVIATIONS used on this Plate, *vide* over.]

LIST OF ABBREVIATIONS.

[*The Roman Numerals indicate Nerves and their Foramina.*]

ac.	Acetabulum.
ac.p.	Acromial process of scapula.
ag.	Angulare.
al.e.	Aliethmoid.
al.n.	Alinasal.
ar.	Articulare.
al.s.	Alisphenoid.
al.sp.	Aliseptal.
a.o.	Antorbital.
a.s.c.	Anterior semicircular canal.
at.	Atlas.
a.t.r.	Anterior tympanic recess.
au.	Auditory capsule.
ax.	Axis.
b.h.br.	Basi-hyobranchial.
b.hy.	Basihyal.
b.o.	Basioccipital.
b.pg.	Basipterygoid.
br.	Ceratobranchial.
b.s.	Basisphenoid.
b.t.	Basitemporal.
c.	Centrum and centrale.
c.a.	Uncinate process.
cd.v.	Caudal vertebra.
c.f.c.	Cranio-facial cleft.
c.hy.	Cerato-hyal.
cl.	Clavicle.
co.	Columella.
cp.	Carpal.
cr.	Coracoid and cervical rib.
cr.g.	Crista galli.
c.ty.	Tympanic cavity.
c.u.	Centralo-ulnare.
c.v.	Cervical vertebræ.
d.	Dentary.
d.c.	Distal carpal.
dg.	Digit.
d.t.	Distal tarsal.
d.r.	Dorsal rib.
d.s.v.	Dorso-sacral vertebræ,
d.v.	Dorsal vertebra.
e.eth.	Ectoethmoid.
e.n.	External nostril.
e.o.	Exoccipital.
Eu.	Eustachian opening.
f.	Frontal and femur.
fb.	Fibula.
fbe.	Fibulare.
f.m.	Foramen magnum.
fr.	Furcula.
g.	Ganglion.
h.	Humerus.
h.s.c.	Horizontal semicircular canal.
i.	Intermedium.
i.a.c.	Interarcticular cartilage.
i.a.p.	Internal angular process.
ic.	Intercentrum.
i.c.	Internal carotid foramen.
i.cl.	Interclavicle.
il.	Ilium.
i.o.f.	Inter-orbital fenestra.
i.pa.	Inter-palatine.
i.r.	Intermedio-radiale.
isc.	Ischium.
i.tb.	Inferior turbinal.
i.tr.	Inter-trabecula.
j.	Jugal.
l.	Lachrymal.
l.c.	Lachrymal canal.
l.s.v.	Lumbo-sacral vertebræ.
m.	Mouth.
mk.	Meckel's cartilage.
m.st.	Metasternum.
mt.c.	Metacarpal.
mt.t.	Metatarsal.
mx.p.	Maxillo-palatine.
n.	Nasal.
n.a.	Neural arch.
nc.	Notochord.
n.f.	Nasal floor.
n.px.	Nasal process of pre-maxillary.
ob.f.	Obturator fenestra.
oc.c.	Occipital condyle.
od.p.	Odontoidprocess.
op.	Opisthotic.
o.s.	Orbitosphenoid.
p.	Parietal.
pa.	Palatine.
p.a.p.	Posterior angular process.
pa.s.	Parasphenoid.
pb.	Pubis.
p.cl.	Posterior clinoid process.
pc.p.	Postcoracoid process of sternum.
pcr.	Precoracoid.
p.c.s.	Pre-costal process of sternum.
p.e.	Perpendicular ethmoid.
pg.	Pterygoid.
ph.	Phalanx.
p.n.	Prenasal rostrum.
pr.i.	Pre-ilium.
pro.	Prootic.
pr.z.	Pre-zygaphophysis.
p.s.	Presphenoid.
p.s.c.	Posterior semicircular canal.
pt.i.	Post-ilium.
pt.z.	Post-zygapophysis.
px.	Premaxilla.
q.	Quadrate.
q.j.	Quadrato-jugal.
r.	Radius.
r.b.s.	Rostrum of basisphenoid (= rostrum of parasphenoid).
re.	Radiale.
r.st.	Rostral process of sternum.
s.ag.	Supra-angulare.
sc.	Scapula.
s.n.	Septum nasi.
s.i.f.	Sacro-ischiatic fenestra.
s.o.	Supra-occipital.
sp.	Splenial.
sp.o.	Sphenotic.
sq.	Squamosal.
s.r.	Sacral rib.
s.sc.	Supra-scapula.
st.	Sternum.
st.k.	Sternal keel.
s.v.	Sacral vertebra.
tb.	Tibial.
t.c.	Tendon-canal.
te.	Tibiale.
t.so.	Tympanic wing of occipital.
ts.	Tarsal.
u.	Ulna.
ue.	Ulnare.
u.s.v.	Uro-sacral vertebræ.
v.	Vomer.
v.a.	Vertebral artery.
v.b.	Vestibule.



W.K.Parker del ad nat. M.P.Parker lith.

West, Newman imp.

ANATIDÆ

LIST OF ABBREVIATIONS.

[*The Roman Numerals indicate Nerves and their Foramina.*]

ac.	Acetabulum.
ac.p.	Acromial process of scapula.
ag.	Angulare.
al.e.	Aliethmoid.
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ar.	Articulare.
al.s.	Alisphenoid.
al.sp.	Aliseptal.
a.o.	Antorbital.
a.s.c.	Anterior semicircular canal.
at.	Atlas.
a.t.r.	Anterior tympanic recess.
au.	Auditory capsule.
ax.	Axis.
b.h.br.	Basi-hyobranchial.
b.hy.	Basihyal.
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b.pg.	Basipterygoid.
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c.ty.	Tympanic cavity.
c.u.	Centralo-ulnare.
c.v.	Cervical vertebræ.
d.	Dentary.
d.c.	Distal carpal.
dg.	Digit.
d.t.	Distal tarsal.
d.r.	Dorsal rib.
d.s.v.	Dorso-sacral vertebræ,
d.v.	Dorsal vertebra.
e.eth.	Ectoethmoid.
e.n.	External nostril.
e.o.	Exoccipital.
Eu.	Eustachian opening.
f.	Frontal and femur.
fb.	Fibula.
fbe.	Fibulare.
f.m.	Foramen magnum.
fr.	Furcula.
g.	Ganglion.
h.	Humerus.
h.s.c.	Horizontal semicircular canal.
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isc.	Ischium.
i.tb.	Inferior turbinal.
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j.	Jugal.
l.	Lachrymal.
l.c.	Lachrymal canal.
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mt.c.	Metacarpal.
mt.t.	Metatarsal.
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n.f.	Nasal floor.
n.px.	Nasal process of pre-maxillary.
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oc.c.	Occipital condyle.
od.p.	Odontoidprocess.
op.	Opisthotic.
o.s.	Orbitosphenoid.
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pa.	Palatine.
p.a.p.	Posterior angular process.
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p.c.s.	Pre-costal process of sternum.
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p.n.	Prenasal rostrum.
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p.s.	Presphenoid.
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s.ag.	Supra-angulare.
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s.n.	Septum nasi.
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s.o.	Supra-occipital.
sp.	Splenial.
sp.o.	Sphenotic.
sq.	Squamosal.
s.r.	Sacral rib.
s.sc.	Supra-scapula.
st.	Sternum.
st.k.	Sternal keel.
s.v.	Sacral vertebra.
tb.	Tibial.
t.c.	Tendon-canal.
te.	Tibiale.
t.oc.	Tympanic wing of occipital.
ts.	Tarsal.
u.	Ulna.
ue.	Ulnare.
u.s.v.	Uro-sacral vertebræ.
v.	Vomer.
v.a.	Vertebral artery.
v.b.	Vestibule.

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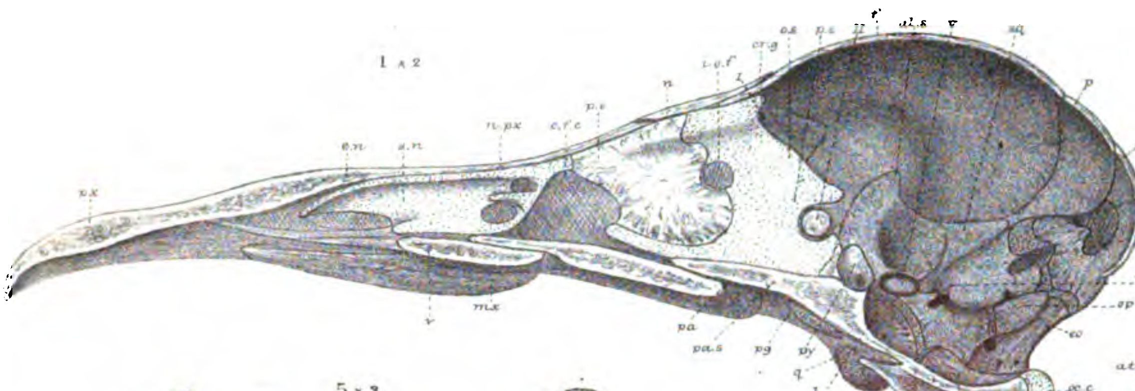

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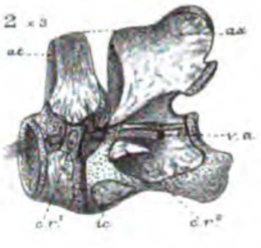

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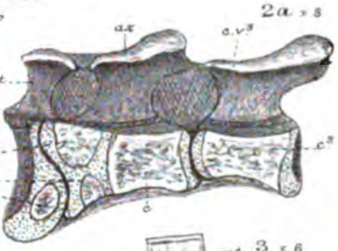

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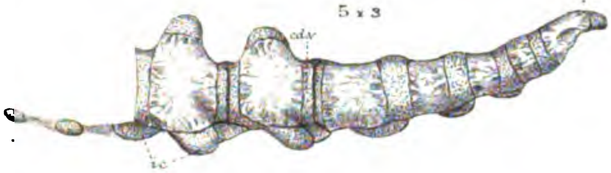

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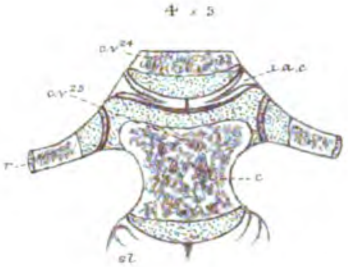

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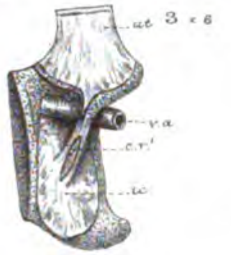

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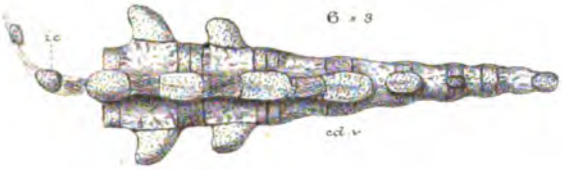

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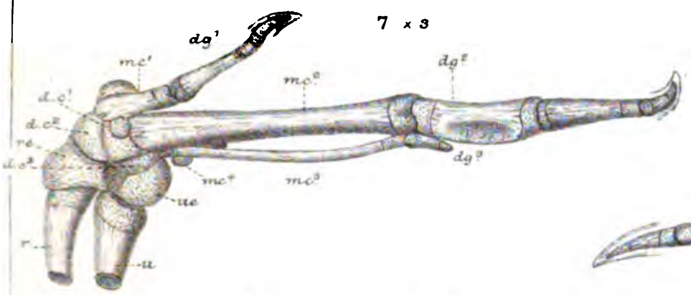

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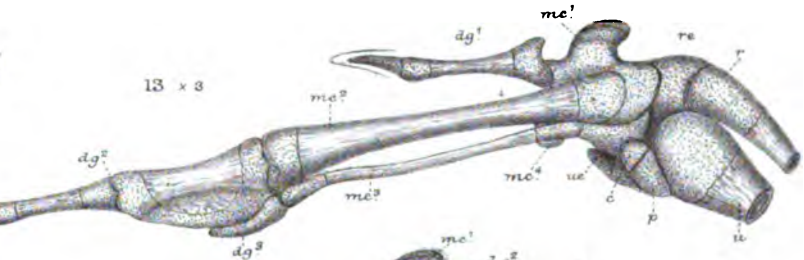

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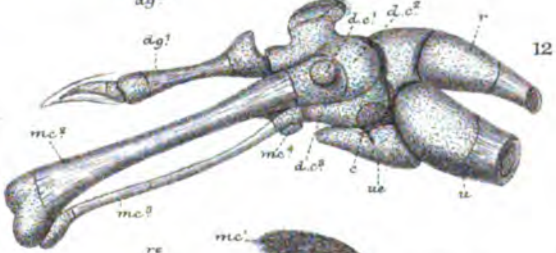

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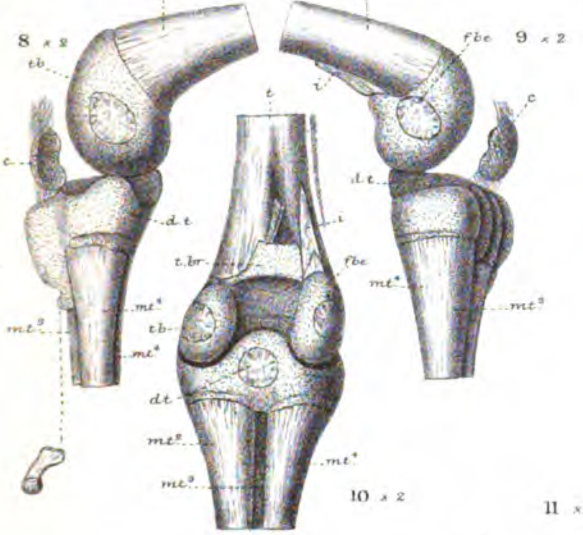
9 × 2

10 × 2



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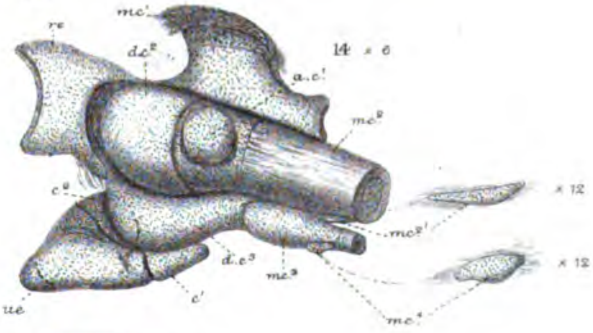

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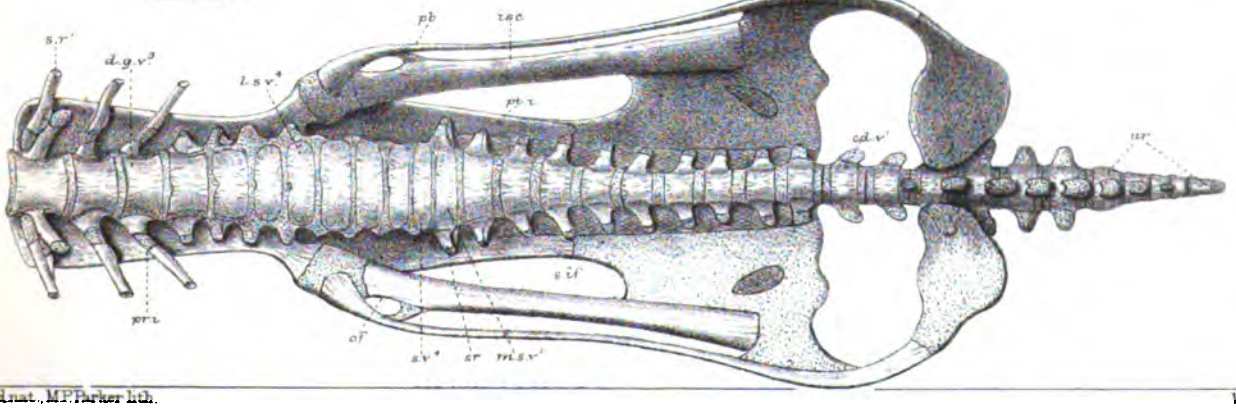


W.K.Parker del.ad nat., M.P.Parker lith.

West, Newman imp.

ANATIDÆ

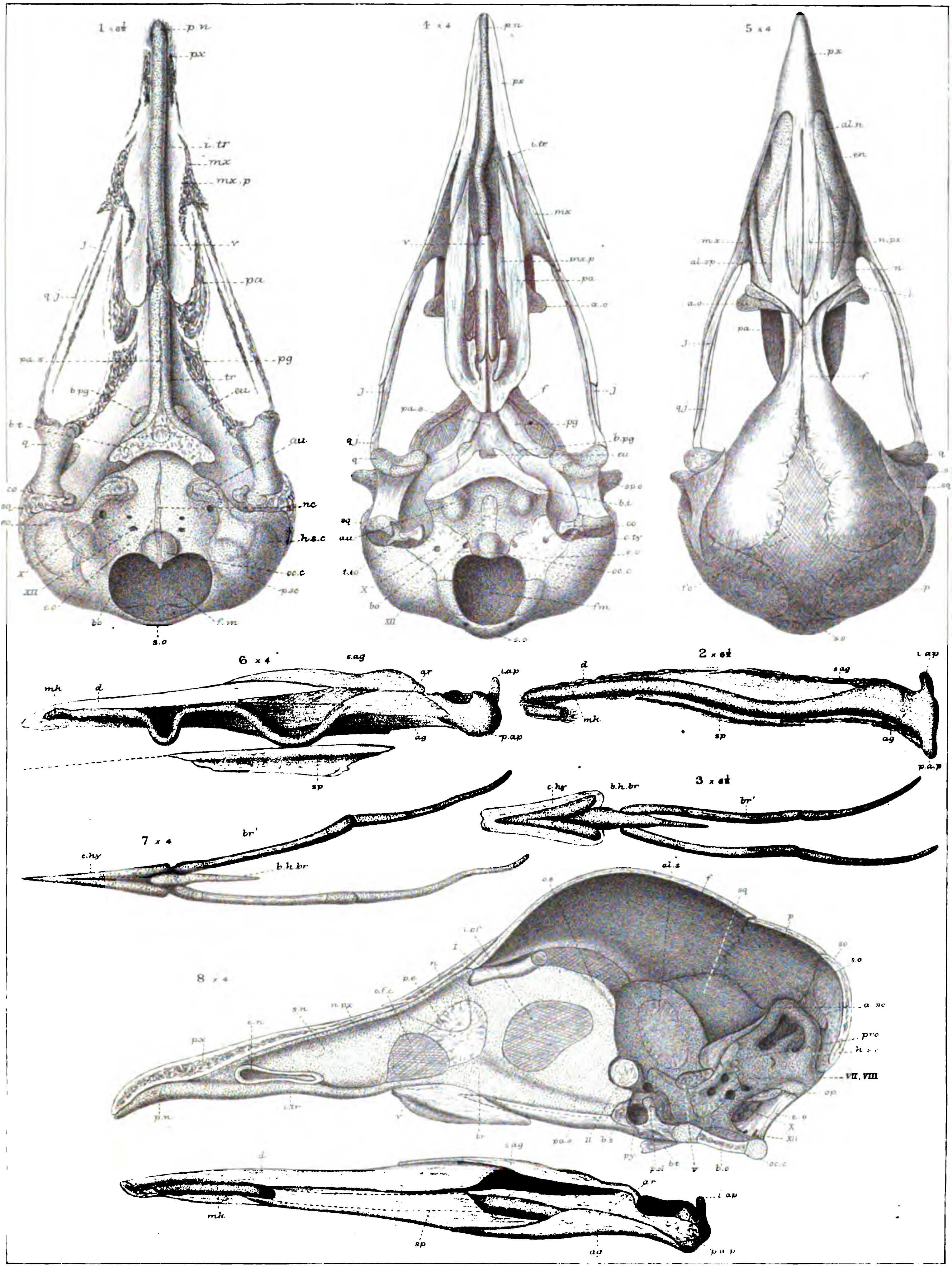
PLATE VI.

MORPHOLOGY OF THE DUCK AND THE AUK TRIBES.

LIST OF ABBREVIATIONS.

[*The Roman Numerals indicate Nerves and their Foramina.*]

ac.	Acetabulum.
ac.p.	Acromial process of scapula.
ag.	Angulare.
al.e.	Aliethmoid.
al.n.	Alinasal.
ar.	Articulare.
al.s.	Alisphenoid.
al.sp.	Aliseptal.
a.o.	Antorbital.
a.s.c.	Anterior semicircular canal.
at.	Atlas.
a.t.r.	Anterior tympanic recess.
au.	Auditory capsule.
ax.	Axis.
b.h.br.	Basi-hyobranchial.
b.hy.	Basihyal.
b.o.	Basioccipital.
b.pg.	Basipterygoid.
br.	Ceratobranchial.
b.s.	Basisphenoid.
b.t.	Basitemporal.
c.	Centrum and centrale.
c.a.	Uncinate process.
cd.v.	Caudal vertebra.
c.f.c.	Cranio-facial cleft.
c.hy.	Cerato-hyal.
cl.	Clavicle.
co.	Columella.
cp.	Carpal.
cr.	Coracoid and cervical rib.
cr.g.	Crista galli.
c.ty.	Tympanic cavity.
c.u.	Centralo-ulnare.
c.v.	Cervical vertebræ.
d.	Dentary.
d.c.	Distal carpal.
dg.	Digit.
d.t.	Distal tarsal.
d.r.	Dorsal rib.
d.s.v.	Dorso-sacral vertebræ,
d.v.	Dorsal vertebra.
e.eth.	Ectoethmoid.
e.n.	External nostril.
e.o.	Exoccipital.
Eu.	Eustachian opening.
f.	Frontal and femur.
fb.	Fibula.
fbe.	Fibulare.
f.m.	Foramen magnum.
fr.	Furcula.
g.	Ganglion.
h.	Humerus.
h.s.c.	Horizontal semicircular canal.
i.	Intermedium.
i.a.c.	Interarcticular cartilage.
i.a.p.	Internal angular process.
ic.	Intercentrum.
i.c.	Internal carotid foramen.
i.cl.	Interclavicle.
il.	Ilium.
i.o.f.	Inter-orbital fenestra.
i.pa.	Inter-palatine.
i.r.	Intermedio-radiale.
isc.	Ischium.
i.tb.	Inferior turbinal.
i.tr.	Inter-trabecula.
j.	Jugal.
l.	Lachrymal.
l.c.	Lachrymal canal.
l.s.v.	Lumbo-sacral vertebræ.
m.	Mouth.
mk.	Meckel's cartilage.
m.st.	Metasternum.
mt.c.	Metacarpal.
mt.t.	Metatarsal.
mx.p.	Maxillo-palatine.
n.	Nasal.
n.a.	Neural arch.
nc.	Notochord.
n.f.	Nasal floor.
n.px.	Nasal process of pre-maxillary.
ob.f.	Obturator fenestra.
oc.c.	Occipital condyle.
od.p.	Odontoidprocess.
op.	Opisthotic.
o.s.	Orbitosphenoid.
p.	Parietal.
pa.	Palatine.
p.a.p.	Posterior angular process.
pa.s.	Parasphenoid.
pb.	Pubis.
p.cl.	Posterior clinoid process.
pc.p.	Postcoracoid process of sternum.
pcr.	Precoracoid.
p.c.s.	Pre-costal process of sternum.
p.e.	Perpendicular ethmoid.
pg.	Pterygoid.
ph.	Phalanx.
p.n.	Prenasal rostrum.
pr.i.	Pre-ilium.
pro.	Proötic.
pr.z.	Pre-zygaphophysis.
p.s.	Presphenoid.
p.s.c.	Posterior semicircular canal.
pt.i.	Post-ilium.
pt.z.	Post-zygapophysis.
px.	Premaxilla.
q.	Quadrate.
q.j.	Quadrato-jugal.
r.	Radius.
r.b.s.	Rostrum of basisphenoid (= rostrum of parasphenoid).
re.	Radiale.
r.st.	Rostral process of sternum.
s.ag.	Supra-angulare.
sc.	Scapula.
s.n.	Septum nasi.
s.i.f.	Sacro-ischiatic fenestra.
s.o.	Supra-occipital.
sp.	Splenial.
sp.o.	Sphenotic.
sq.	Squamosal.
s.r.	Sacral rib.
s.sc.	Supra-scapula.
st.	Sternum.
st.k.	Sternal keel.
s.v.	Sacral vertebra.
tb.	Tibial.
t.c.	Tendon-canal.
te.	Tibiale.
t.eo.	Tympanic wing of occipital.
ts.	Tarsal.
u.	Ulna.
ue.	Ulnare.
u.s.v.	Uro-sacral vertebræ.
v.	Vomer.
v.a.	Vertebral artery.
v.b.	Vestibule.



W.K. Parker del ad nat. M.P. Parker lith. West, Newman imp.

ALCIDÆ.

PLATE VII.

MORPHOLOGY OF THE DUCK AND THE AUK TRIBES.

EXPLANATION OF PLATE VII.

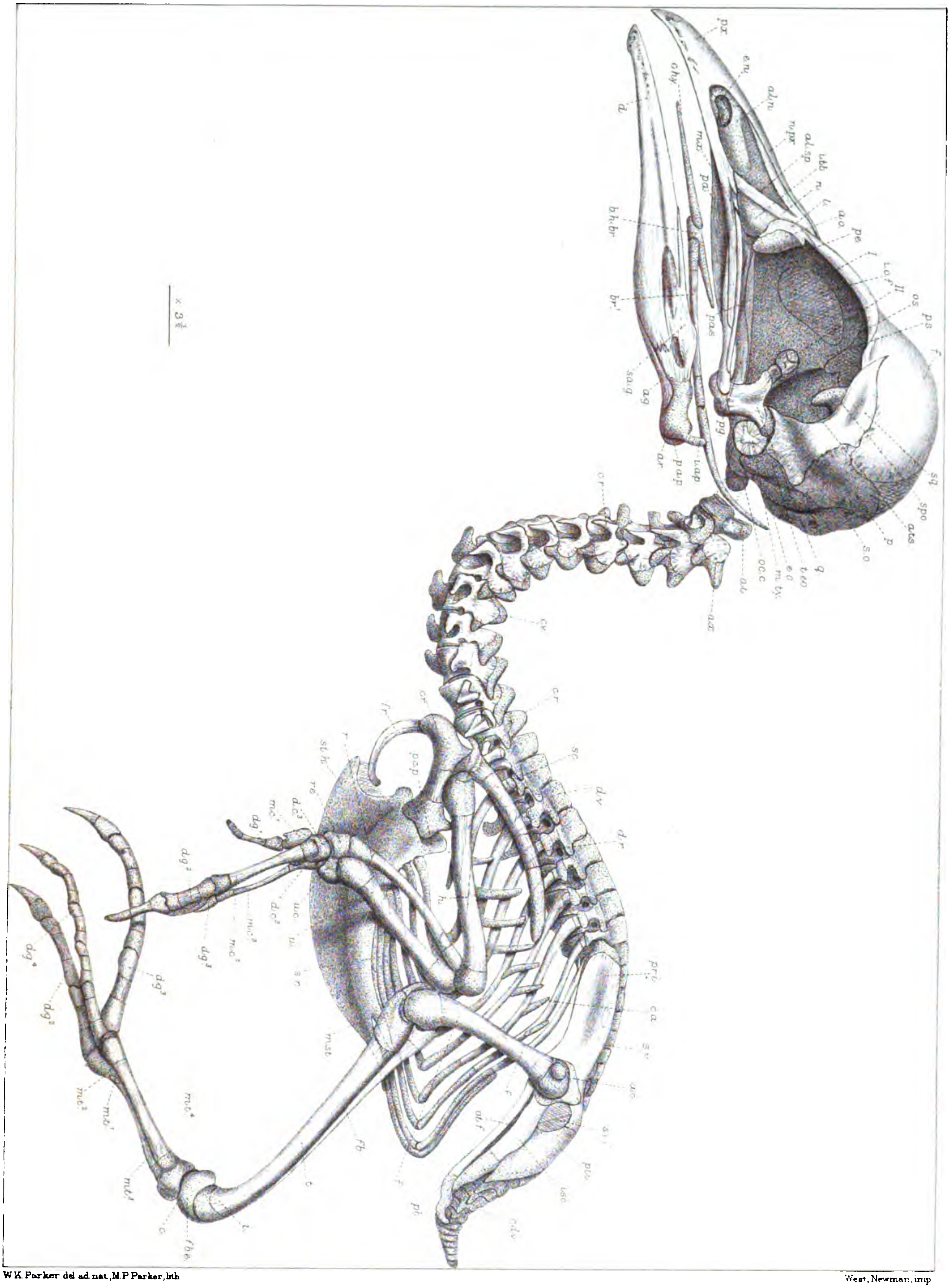
Fig.		Number of times magnified.
1.	*Uria troile;* 2nd stage; embryo two-thirds ripe; skeleton; side view, .	3½ diameters.

[For LIST OF ABBREVIATIONS used on this Plate, *vide* over.]

LIST OF ABBREVIATIONS.

[*The Roman Numerals indicate Nerves and their Foramina.*]

ac.	Acetabulum.
ac.p.	Acromial process of scapula.
ag.	Angulare.
al.e.	Aliethmoid.
al.n.	Alinasal.
ar.	Articulare.
al.s.	Alisphenoid.
al.sp.	Aliseptal.
a.o.	Antorbital.
a.s.c.	Anterior semicircular canal.
at.	Atlas.
a.t.r.	Anterior tympanic recess.
au.	Auditory capsule.
ax.	Axis.
b.h.br.	Basi-hyobranchial.
b.hy.	Basihyal.
b.o.	Basioccipital.
b.pg.	Basipterygoid.
br.	Ceratobranchial.
b.s.	Basisphenoid.
b.t.	Basitemporal.
c.	Centrum and centrale.
c.a.	Uncinate process.
cd.v.	Caudal vertebra.
c.f.c.	Cranio-facial cleft.
c.hy.	Cerato-hyal.
cl.	Clavicle.
co.	Columella.
cp.	Carpal.
cr.	Coracoid and cervical rib.
cr.g.	Crista galli.
c.ty.	Tympanic cavity.
c.u.	Centralo-ulnare.
c.v.	Cervical vertebræ.
d.	Dentary.
d.c.	Distal carpal.
dg.	Digit.
d.t.	Distal tarsal.
d.r.	Dorsal rib.
d.s.v.	Dorso-sacral vertebræ,
d.v.	Dorsal vertebra.
e.eth.	Ectoethmoid.
e.n.	External nostril.
e.o.	Exoccipital.
Eu.	Eustachian opening.
f.	Frontal and femur.
fb.	Fibula.
fbe.	Fibulare.
f.m.	Foramen magnum.
fr.	Furcula.
g.	Ganglion.
h.	Humerus.
h.s.c.	Horizontal semicircular canal.
i.	Intermedium.
i.a.c.	Interarcticular cartilage.
i.a.p.	Internal angular process.
ic.	Intercentrum.
i.c.	Internal carotid foramen.
i.cl.	Interclavicle.
il.	Ilium.
i.o.f.	Inter-orbital fenestra.
i.pa.	Inter-palatine.
i.r.	Intermedio-radiale.
isc.	Ischium.
i.tb.	Inferior turbinal.
i.tr.	Inter-trabecula.
j.	Jugal.
l.	Lachrymal.
l.c.	Lachrymal canal.
l.s.v.	Lumbo-sacral vertebræ.
m.	Mouth.
mk.	Meckel's cartilage.
m.st.	Metasternum.
mt.c.	Metacarpal.
mt.t.	Metatarsal.
mx.p.	Maxillo-palatine.
n.	Nasal.
n.a.	Neural arch.
nc.	Notochord.
n.f.	Nasal floor.
n.px.	Nasal process of pre-maxillary.
ob.f.	Obturator fenestra.
oc.c.	Occipital condyle.
od.p.	Odontoidprocess.
op.	Opisthotic.
o.s.	Orbitosphenoid.
p.	Parietal.
pa.	Palatine.
p.a.p.	Posterior angular process.
pa.s.	Parasphenoid.
pb.	Pubis.
p.cl.	Posterior clinoid process.
pc.p.	Postcoracoid process of sternum.
pcr.	Precoracoid.
p.c.s.	Pre-costal process of sternum.
p.e.	Perpendicular ethmoid.
pg.	Pterygoid.
ph.	Phalanx.
p.n.	Prenasal rostrum.
pr.i.	Pre-ilium.
pro.	Prootic.
pr.z.	Pre-zygaphophysis.
p.s.	Presphenoid.
p.s.c.	Posterior semicircular canal.
pt.i.	Post-ilium.
pt.z.	Post-zygapophysis.
px.	Premaxilla.
q.	Quadrate.
q.j.	Quadrato-jugal.
r.	Radius.
r.b.s.	Rostrum of basisphenoid (= rostrum of parasphenoid).
re.	Radiale.
r.st.	Rostral process of sternum.
s.ag.	Supra-angulare.
sc.	Scapula.
s.n.	Septum nasi.
s.i.f.	Sacro-ischiatic fenestra.
s.o.	Supra-occipital.
sp.	Splenial.
sp.o.	Sphenotic.
sq.	Squamosal.
s.r.	Sacral rib.
s.sc.	Supra-scapula.
st.	Sternum.
st.k.	Sternal keel.
s.v.	Sacral vertebra.
tb.	Tibial.
t.c.	Tendon-canal.
te.	Tibiale.
t.eo.	Tympanic wing of occipital.
ts.	Tarsal.
u.	Ulna.
ue.	Ulnare.
u.s.v.	Uro-sacral vertebræ.
v.	Vomer.
v.a.	Vertebral artery.
v.b.	Vestibule.



W K Parker del ad nat, M P Parker, lith

West, Newman, imp

ALCIDÆ

PLATE VIII.

MORPHOLOGY OF THE DUCK AND THE AUK TRIBES.

EXPLANATION OF PLATE VIII.

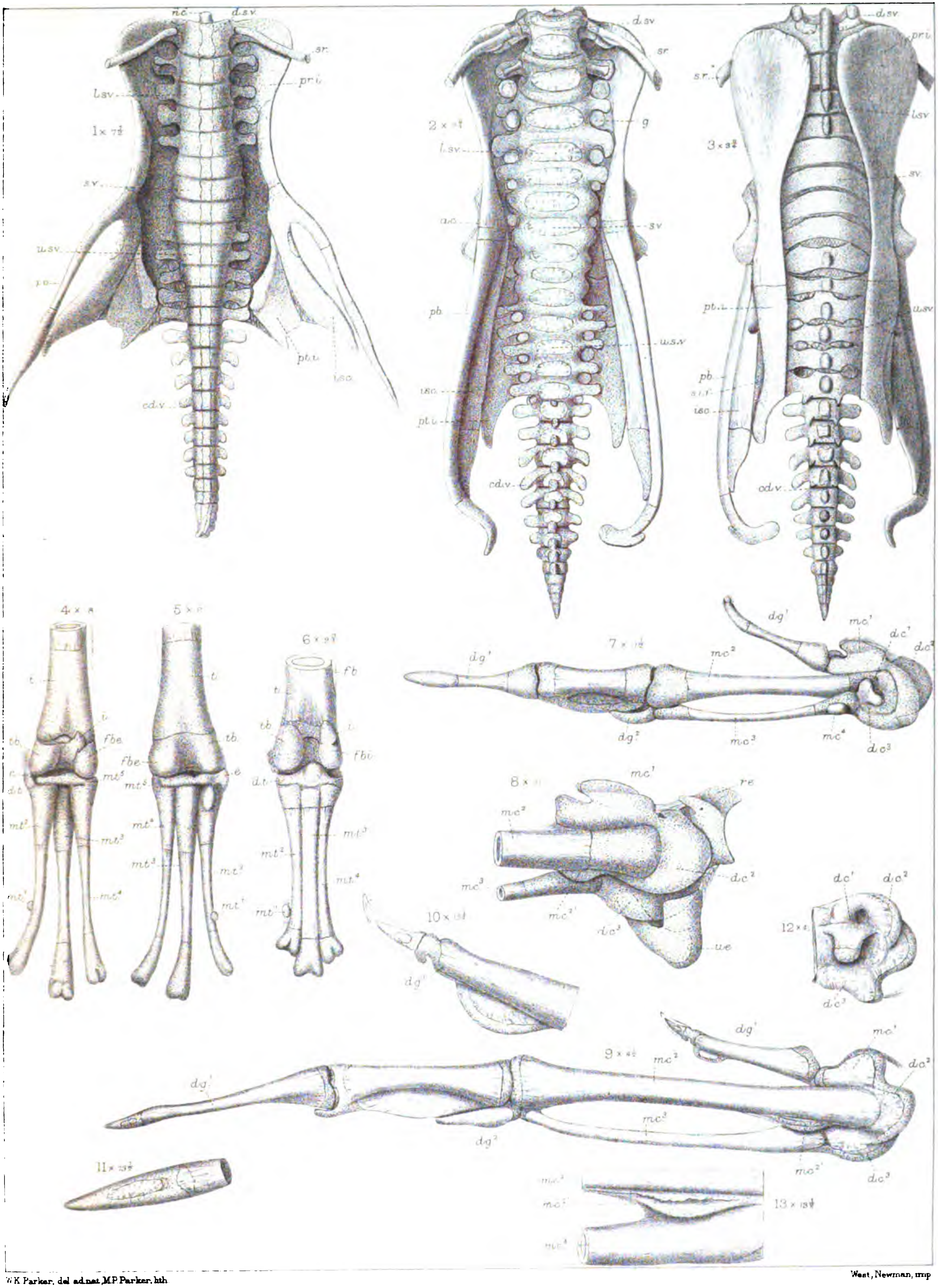
Fig.		Number of times magnified.
1.	*Uria troile;* 1st stage; pelvis; lower view,	7⅓ diameters.
2.	The same; 3rd stage; pelvis; lower view,	3⅔ diameters.
3.	The same; same object; upper view,	3⅔ diameters.
4.	The same; 1st stage; distal part of leg; front view,	8 diameters.
5.	The same; same object; hind view,	8 diameters.
6.	The same; 3rd stage; part of leg; front view,	3⅔ diameters.
7.	The same; manus of 2nd stage; inner view,	7⅓ diameters.
8.	Part of same; outer view,	11 diameters.
9.	*Ciceronia pusilla;* distal part of wing; outer view,	4⅓ diameters.
10.	The same; distal part of pollex,	13⅓ diameters.
11.	The same; distal part of index,	13⅓ diameters.
12.	The same; proximal part of manus; inner view,	4½ diameters.
13.	The same; part of fig. 9,	13⅓ diameters.

[For LIST OF ABBREVIATIONS used on this Plate, *vide* over.]

LIST OF ABBREVIATIONS.

[*The Roman Numerals indicate Nerves and their Foramina.*]

ac.	Acetabulum.
ac.p.	Acromial process of scapula.
ag.	Angulare.
al.e.	Aliethmoid.
al.n.	Alinasal.
ar.	Articulare.
al.s.	Alisphenoid.
al.sp.	Aliseptal.
a.o.	Antorbital.
a.s.c.	Anterior semicircular canal.
at.	Atlas.
a.t.r.	Anterior tympanic recess.
au.	Auditory capsule.
ax.	Axis.
b.h.br.	Basi-hyobranchial.
b.hy.	Basihyal.
b.o.	Basioccipital.
b.pg.	Basipterygoid.
br.	Ceratobranchial.
b.s.	Basisphenoid.
b.t.	Basitemporal.
c.	Centrum and centrale.
c.a.	Uncinate process.
cd.v.	Caudal vertebra.
c.f.c.	Cranio-facial cleft.
c.hy.	Cerato-hyal.
cl.	Clavicle.
co.	Columella.
cp.	Carpal.
cr.	Coracoid and cervical rib.
cr.g.	Crista galli.
c.ty.	Tympanic cavity.
c.u.	Centralo-ulnare.
c.v.	Cervical vertebræ.
d.	Dentary.
d.c.	Distal carpal.
dg.	Digit.
d.t.	Distal tarsal.
d.r.	Dorsal rib.
d.s.v.	Dorso-sacral vertebræ,
d.v.	Dorsal vertebra.
e.eth.	Ectoethmoid.
e.n.	External nostril.
e.o.	Exoccipital.
Eu.	Eustachian opening.
f.	Frontal and femur.
fb.	Fibula.
fbe.	Fibulare.
f.m.	Foramen magnum.
fr.	Furcula.
g.	Ganglion.
h.	Humerus.
h.s.c.	Horizontal semicircular canal.
i.	Intermedium.
i.a.c.	Interarcticular cartilage.
i.a.p.	Internal angular process.
ic.	Intercentrum.
i.c.	Internal carotid foramen.
i.cl.	Interclavicle.
il.	Ilium.
i.o.f.	Inter-orbital fenestra.
i.pa.	Inter-palatine.
i.r.	Intermedio-radiale.
isc.	Ischium.
i.tb.	Inferior turbinal.
i.tr.	Inter-trabecula.
j.	Jugal.
l.	Lachrymal.
l.c.	Lachrymal canal.
l.s.v.	Lumbo-sacral vertebræ.
m.	Mouth.
mk.	Meckel's cartilage.
m.st.	Metasternum.
mt.c.	Metacarpal.
mt.t.	Metatarsal.
mx.p.	Maxillo-palatine.
n.	Nasal.
n.a.	Neural arch.
nc.	Notochord.
n.f.	Nasal floor.
n.px.	Nasal process of pre-maxillary.
ob.f.	Obturator fenestra.
oc.c.	Occipital condyle.
od.p.	Odontoidprocess.
op.	Opisthotic.
o.s.	Orbitosphenoid.
p.	Parietal.
pa.	Palatine.
p.a.p.	Posterior angular process.
pa.s.	Parasphenoid.
pb.	Pubis.
p.cl.	Posterior clinoid process.
pc.p.	Postcoracoid process of sternum.
pcr.	Precoracoid.
p.c.s.	Pre-costal process of sternum.
p.e.	Perpendicular ethmoid.
pg.	Pterygoid.
ph.	Phalanx.
p.n.	Prenasal rostrum.
pr.i.	Pre-ilium.
pro.	Prootic.
pr.z.	Pre-zygaphophysis.
p.s.	Presphenoid.
p.s.c.	Posterior semicircular canal.
pt.i.	Post-ilium.
pt.z.	Post-zygapophysis.
px.	Premaxilla.
q.	Quadrate.
q.j.	Quadrato-jugal.
r.	Radius.
r.b.s.	Rostrum of basisphenoid (= rostrum of parasphenoid).
re.	Radiale.
r.st.	Rostral process of sternum.
s.ag.	Supra-angulare.
sc.	Scapula.
s.n.	Septum nasi.
s.i.f.	Sacro-ischiatic fenestra.
s.o.	Supra-occipital.
sp.	Splenial.
sp.o.	Sphenotic.
sq.	Squamosal.
s.r.	Sacral rib.
s.sc.	Supra-scapula.
st.	Sternum.
st.k.	Sternal keel.
s.v.	Sacral vertebra.
tb.	Tibial.
t.c.	Tendon-canal.
te.	Tibiale.
t.eo.	Tympanic wing of occipital.
ts.	Tarsal.
u.	Ulna.
ue.	Ulnare.
u.s.v.	Uro-sacral vertebræ.
v.	Vomer.
v.a.	Vertebral artery.
v.b.	Vestibule.



W.K. Parker, del ad nat. M.P. Parker, lith.

West, Newman, imp.

ALCIDÆ.

PLATE IX.

MORPHOLOGY OF THE DUCK AND THE AUK TRIBES.

EXPLANATION OF PLATE IX.

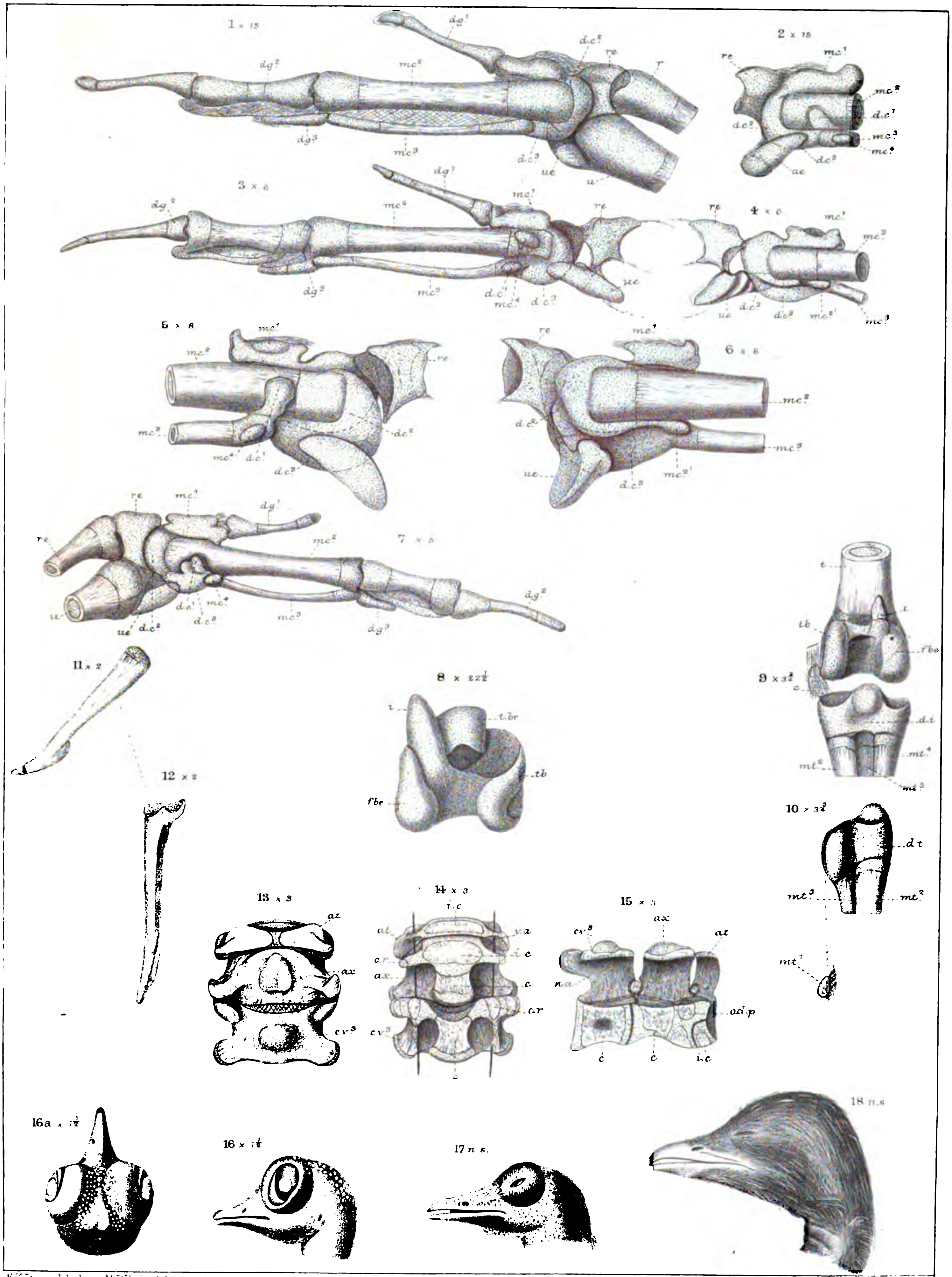
Fig.		Number of times magnified.
1.	*Alca torda;* 1st stage; one-third ripe embryo; distal part of wing; outer view, ...	15 diameters.
2.	The same; part of same object; inner view, ...	15 diameters.
3.	The same; 2nd stage; three-quarter ripe embryo distal part of wing; inner view, ...	6 diameters.
4.	The same; same object; outer view, ...	6 diameters.
5.	The same; 3rd stage; nearly ripe embryo proximal part of manus; inner view, ...	8 diameters.
6.	The same; same object; outer view, ...	8 diameters.
8.	The same; 1st stage; upper part of tarsus; front view, ...	22½ diameters.
7.	*Uria troile;* 3rd stage; distal part of wing; inner view, . . .	5 diameters.
9.	The same; 3rd stage; ankle-joint; front view, ...	3⅘ diameters.
10.	The same; lower part of same object; inner view, ...	3⅘ diameters.
11.	The same; adult; distal part of pollex, ...	2 diameters.
12.	The same; same skeleton; distal part of index, ...	2 diameters.
16, 16*a*.	The same; head of embryo, one-third ripe; 1st stage, . . .	1½ diameters.
17.	The same; do. do. two-thirds ripe; 2nd stage, . . .	Natural size.
18.	The same; do. do. nearly ripe; 3rd stage, ...	Natural size.
13.	*Casuarius bennettii;* ripe embryo; first three vertebræ; upper view, .	3 diameters.
14.	The same; same object; lower view, ...	3 diameters.
15.	The same; same object; vertical section, ...	3 diameters.

[For LIST OF ABBREVIATIONS used on this Plate, *vide* over.

LIST OF ABBREVIATIONS.

[*The Roman Numerals indicate Nerves and their Foramina.*]

ac.	Acetabulum.
ac.p.	Acromial process of scapula.
ag.	Angulare.
al.e.	Aliethmoid.
al.n.	Alinasal.
ar.	Articulare.
al.s.	Alisphenoid.
al.sp.	Aliseptal.
a.o.	Antorbital.
a.s.c.	Anterior semicircular canal.
at.	Atlas.
a.t.r.	Anterior tympanic recess.
au.	Auditory capsule.
ax.	Axis.
b.h.br.	Basi-hyobranchial.
b.hy.	Basihyal.
b.o.	Basioccipital.
b.pg.	Basipterygoid.
br.	Ceratobranchial.
b.s.	Basisphenoid.
b.t.	Basitemporal.
c.	Centrum and centrale.
c.a.	Uncinate process.
cd.v.	Caudal vertebra.
c.f.c.	Cranio-facial cleft.
c.hy.	Cerato-hyal.
cl.	Clavicle.
co.	Columella.
cp.	Carpal.
cr.	Coracoid and cervical rib.
cr.g.	Crista galli.
c.ty.	Tympanic cavity.
c.u.	Centralo-ulnare.
c.v.	Cervical vertebræ.
d.	Dentary.
d.c.	Distal carpal.
dg.	Digit.
d.t.	Distal tarsal.
d.r.	Dorsal rib.
d.s.v.	Dorso-sacral vertebræ,
d.v.	Dorsal vertebra.
e.eth.	Ectoethmoid.
e.n.	External nostril.
e.o.	Exoccipital.
Eu.	Eustachian opening.
f.	Frontal and femur.
fb.	Fibula.
fbe.	Fibulare.
f.m.	Foramen magnum.
fr.	Furcula.
g.	Ganglion.
h.	Humerus.
h.s.c.	Horizontal semicircular canal.
i.	Intermedium.
i.a.c.	Interarcticular cartilage.
i.a.p.	Internal angular process.
ic.	Intercentrum.
i.c.	Internal carotid foramen.
i.cl.	Interclavicle.
il.	Ilium.
i.o.f.	Inter-orbital fenestra.
i.pa.	Inter-palatine.
i.r.	Intermedio-radiale.
isc.	Ischium.
i.tb.	Inferior turbinal.
i.tr.	Inter-trabecula.
j.	Jugal.
l.	Lachrymal.
l.c.	Lachrymal canal.
l.s.v.	Lumbo-sacral vertebræ.
m.	Mouth.
mk.	Meckel's cartilage.
m.st.	Metasternum.
mt.c.	Metacarpal.
mt.t.	Metatarsal.
mx.p.	Maxillo-palatine.
n.	Nasal.
n.a.	Neural arch.
nc.	Notochord.
n.f.	Nasal floor.
n.px.	Nasal process of pre-maxillary.
ob.f.	Obturator fenestra.
oc.c.	Occipital condyle.
od.p.	Odontoidprocess.
op.	Opisthotic.
o.s.	Orbitosphenoid.
p.	Parietal.
pa.	Palatine.
p.a.p.	Posterior angular process.
pa.s.	Parasphenoid.
pb.	Pubis.
p.cl.	Posterior clinoid process.
pc.p.	Postcoracoid process of sternum.
pcr.	Precoracoid.
p.c.s.	Pre-costal process of sternum.
p.e.	Perpendicular ethmoid.
pg.	Pterygoid.
ph.	Phalanx.
p.n.	Prenasal rostrum.
pr.i.	Pre-ilium.
pro.	Prootic.
pr.z.	Pre-zygaphophysis.
p.s.	Presphenoid.
p.s.c.	Posterior semicircular canal.
pt.i.	Post-ilium.
pt.z.	Post-zygapophysis.
px.	Premaxilla.
q.	Quadrate.
q.j.	Quadrato-jugal.
r.	Radius.
r.b.s.	Rostrum of basisphenoid (= rostrum of parasphenoid).
re.	Radiale.
r.st.	Rostral process of sternum.
s.ag.	Supra-angulare.
sc.	Scapula.
s.n.	Septum nasi.
s.i.f.	Sacro-ischiatic fenestra.
s.o.	Supra-occipital.
sp.	Splenial.
sp.o.	Sphenotic.
sq.	Squamosal.
s.r.	Sacral rib.
s.sc.	Supra-scapula.
st.	Sternum.
st.k.	Sternal keel.
s.v.	Sacral vertebra.
tb.	Tibial.
t.c.	Tendon-canal.
te.	Tibiale.
t.eo.	Tympanic wing of occipital.
ts.	Tarsal.
u.	Ulna.
ue.	Ulnare.
u.s.v.	Uro-sacral vertebræ.
v.	Vomer.
v.a.	Vertebral artery.
v.b.	Vestibule.



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